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Generalist predators function as pest specialists: examining diet composition of spiders and ladybeetles across rice crop stages

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Abstract

1. Biocontrol, the use of natural enemies to manage pests, has a long history in agriculture. It has gained renewed interest because of its importance in sustainable agriculture.
2. To solve a long-standing puzzle in biocontrol—how well the ubiquitous generalist arthropod predators (GAPs) function as biocontrol agents—this study aimed to 1) quantify the diet composition of GAPs (spiders and ladybeetles) at different crop stages using stable isotope analysis, 2) examine the consistency of GAPs in pest consumption over years, and 3) investigate how abiotic and biotic factors (farm type, crop stage, surrounding vegetation, and relative prey abundance) affect pest consumption by GAPs.
3. Specifically, we sampled arthropod prey and GAPs in seven pairs of sub-tropical organic and conventional rice farms over crop stages (seedling, tillering, flowering, and ripening) in three consecutive years. Among our sweep-net samples, 352 arthropod predator and 828 prey isotope samples were analyzed to infer predator-prey interactions.
4. Our results show the following: a) The proportion of rice pests in GAPs' diets in both organic and conventional rice farms increased over the crop season, from 21-47% at the tillering stage to 80-97% at the ripening stage, across the three study years. The high percentage in pest consumption at late crop stages (flowering and ripening) suggests that GAPs can function as specialists in pest management during the critical period of crop

production. Regarding individual predator groups, spiders and ladybeetles exhibited distinct dietary patterns over crop stages. b) The high pest consumption by GAPs at late crop stages was similar across years despite variable climatic conditions and prey availability, suggesting a consistency in GAP feeding habits and biocontrol value. c) The proportion of rice pests in GAPs' diets varied with farm type and crop stage (e.g., higher in conventional farms and during flowering/ripening stages).

5. By quantifying the diet composition of GAPs over crop stages, farm types, and years, this study reveals that generalist predators have potential to produce a stable, predictable top-down effect on pests in rice agro-ecosystems. Therefore, promoting the field densities of ubiquitous generalist predators will likely enhance pest management and support sustainable agriculture.

Keywords: biocontrol, trophic interactions, rice paddy, organic and conventional farms, stable isotope analysis

1. Introduction

Using natural arthropod enemies for pest control has a long history in agriculture. The earliest record of biocontrol was documented in the book *Plants of the Southern Regions* (*ca.* 304 A.D.): people sold ants and their nests in the markets to control citrus insect pests (Huang & Yang 1987). While synthetic pesticides have become the main method for controlling pests in the past century, this comes at a cost, such as posing risks to people, reducing biodiversity and hampering ecosystem functions (Geiger et al. 2010; Kehoe et al. 2017). As agriculture has become the largest land use type worldwide and a major driver for the global biodiversity crisis in Anthropocene (Campbell et al. 2017), a shift from synthetic pesticides to environmentally friendly practices (e.g., biocontrol) is urgently needed to make agriculture more sustainable (Gomiero, Pimentel & Paoletti 2011). For example, the European Commission has announced its plan to reduce the use of chemical pesticides in European Union agricultural systems by 50% by 2030 (European Commission 2020). To achieve this ambitious sustainability goal, biocontrol by natural enemies has been considered a key approach and has regained importance in modern agriculture (Baker, Green & Loker 2020; Power 2010).

Natural enemies used for pest control can be classified into two major groups based on their prey range: specialist and generalist predators. While specialist predators (e.g., parasitoid wasps) have been widely advocated in agriculture because they target specific pest species and produce less undesirable non-target effects (Stiling & Cornelissen 2005), generalist predators (e.g., spiders) have been increasingly appreciated for their conspicuous existence and consistent biocontrol effect on pests (Gajski et al. 2023; Hsu, Ou & Ho 2021; Michalko, Pekár & Entling 2019; Stiling & Cornelissen 2005; Symondson, Sunderland & Greenstone 2002). For example, generalist predators were commonly reported in various agro-ecosystems (Cuff et al. 2022;

Mezőfi et al. 2020; Morente & Ruano 2022) and significantly reduced pest abundance in approximately 75% of cases in 181 field manipulative studies (Symondson, Sunderland & Greenstone 2002). Moreover, a meta-analysis suggests that generalist predators may exert stronger biocontrol effects on pest populations over time compared to specialists (Stiling & Cornelissen 2005).

While the value of generalist predators has been increasingly appreciated, a few fundamental knowledge gaps need to be filled to better understand their biocontrol potential and the underlying mechanisms in agro-ecosystems. For example, while studies have qualitatively analyzed the diets of generalist predators (e.g., using molecular gut content analysis to identify prey species) (Albertini et al. 2018; Eitzinger & Traugott 2011; Ingrao et al. 2017), very few have quantified their diet composition over a growth season in the field (knowledge gap 1) (Hsu, Ou & Ho 2021; Otieno, Butler & Pryke 2023). Quantifying diet composition (e.g., the proportions of different prey items in the predators' diet) will help address concerns that generalist predators may switch their diet from pests to alternative prey or interfere with each other (e.g., intraguild predation), thereby reducing their pest control effectiveness (Cuff et al. 2022; Hambäck et al. 2021; Michalko, Pekár & Entling 2019). For instance, if generalist predators still consume a high proportion of pests in their diet with the presence of alternative prey in the field, this result would help end a long debate on whether generalist predators serve well as biocontrol agents (Krey et al. 2017; Michalko, Pekár & Entling 2019; Symondson, Sunderland & Greenstone 2002). Moreover, fluctuations in abiotic factors and habitat conditions reportedly contribute to seasonal and yearly variations in prey density and species composition in agro-ecosystems (Dominik et al. 2018; Settle et al. 1996; Wardle et al. 1999), potentially influencing predator foraging behavior. Therefore, examining the consistency of pest consumption by generalist predators in the field over years is crucial to evaluate the stability of these predators as biocontrol agents in agriculture, although this information is lacking (knowledge gap 2).

To understand the mechanisms underlying the biocontrol effect of generalist predators, we also need to examine how their diet composition in agro-ecosystems is affected by various abiotic and biotic factors (e.g., crop stage, farm type, relative prey abundance, and surrounding vegetation) (knowledge gap 3). First, foraging behavior of generalist predators is strongly influenced by prey availability and species interactions (e.g., predator-prey interactions). Because arthropod community composition (e.g., pest vs. alternative prey density) may vary with crop stages and affect predator-prey trophic interactions (Roubinet et al. 2017), it is important to examine how crop stage affects the pest consumption by generalist predators within a growth season. Second, we should examine whether farming practices (e.g., organic and conventional) influence the diet composition of predators (e.g., pest consumption) (Birkhofer et al. 2011). This will demonstrate whether generalist predators provide varying biocontrol values in specific farm types. Third, we should investigate the relationship between the relative prey abundance and the diet composition of their predators. This will clarify whether pest abundance or predator preference mainly explains the pest consumption by predators (Eitzinger et al. 2019; Kuusk & Ekbom 2012; Roubinet et al. 2017; Wise, Moldenhauer & Halaj 2006). Lastly, we should examine how surrounding vegetation (e.g., forest cover) affects the diet composition of generalist predators. While surrounding vegetation reportedly affected arthropod diversity and predator-prey interactions in agro-ecosystems (Altieri 1999; Altieri & Letourneau 1982; Barbosa & Castellanos 2005; Diehl et al. 2013; Lichtenberg et al. 2017), its effect on predators' diet composition is unclear. Understanding this will provide insights for managing the agricultural landscape and promoting biocontrol services by generalist predators.

To address these three knowledge gaps, this study aimed to 1) quantify the diet composition of generalist predators, 2) examine the consistency of predators in pest consumption over years, and 3) investigate how abiotic and biotic factors may affect the diet composition of these predators. Filling these gaps will provide insights for applying generalist predators in biocontrol programs. Specifically, this study sampled arthropod prey and generalist arthropod predators (GAPs) in sub-tropical organic and conventional rice farms over the rice growth season (seedling, tillering, flowering, and ripening stages) in central Taiwan from 2017 to 2019, and quantified the diet composition of GAPs (ladybeetles and spiders) at each rice stage using stable isotope analysis ($\delta^{13}C$ and $\delta^{15}N$) (Fig. 1). Stable isotope analysis has been widely applied in ecology to infer predator-prey trophic interactions and estimate the proportional contribution of different prey sources to predators' diets across various ecological levels, from individuals to trophic groups (Boecklen et al. 2011; Layman et al. 2012; Post 2002). Compared to "snap-shot" techniques (e.g., field observations and molecular gut content analysis), which primarily provide qualitative information about the presence or absence of prey items in predators' diets, stable isotope analysis (e.g., Bayesian stable isotope mixing models) quantifies the biomass proportion of different prey items in predators' diets over an extended time period (Newton 2016; Stock et al. 2018). Although GAPs may consume various prey items, we expected them to consistently consume a high proportion of pests in their diet at late crop stages regardless of the year, due to the high pest densities in this period. We also expected that the diet composition of GAPs would be affected by local abiotic and biotic factors, such as farm type (farming practice), crop stage, surrounding vegetation (percent forest cover), and the relative abundance of pests in the field.

2. Materials and Methods

2.1. Study system and sample collection

We collected terrestrial arthropods in paired organic and conventional rice farms in subtropical Taiwan (120.656-120.721 °E; 24.364-24.489 °N) from 2017 to 2019 (three farm pairs in 2017 and seven farm pairs each in 2018 and 2019) (Fig. 1a). While farms in the same pair were relatively close to each other (e.g., within a few hundred meters in distance), different farm pairs were at least 1 km apart from each other to reduce confounding effects. The study farms were 0.2 hectares on average and irrigated with surface water. The organic farms were managed with organic fertilizers (manure; 2-3 applications/crop season) and natural pesticides (tea saponins; 1 application/crop season during the seedling or tillering stage). The conventional farms were managed with synthetic nitrogen fertilizers (2-3 applications/crop season) and organophosphate pesticides (1 application/crop season during the tillering or flowering stage). At each major rice crop stage (seedling, tillering, flowering, and ripening stages) during the growing season (April - July) in each study year, we collected arthropod samples by sweep-netting (36 cm in diameter with a mesh size of 0.2 × 0.2 mm) the crop canopy 30 times in each of two transects inside a rice field. Each transect (ca 30 m long) was parallel to but 1.5m away from a randomly selected farm ridge. Samples were sealed in bags without chemical preservatives, iced, and transferred to refrigerator (−20ºC) in the laboratory. The arthropod samples from the two transects in each farm were pooled to represent the farm. We identified and counted arthropods under a dissecting scope to the lowest possible taxonomic level (usually species, genus, or family). Main orders, families, and genera have been documented in a previous study by Hsu et al. (Hsu, Ou & Ho 2021). Note that the samples collected in 2018 for this study are the same as those in Hsu *et al.* (2021), but different statistical models were applied.

2.2. Stable isotope analysis of arthropod samples

After identification, arthropod samples were prepared for stable isotope analysis. First, samples were oven dried (50ºC) for one week, ground, and weighed into individual tin capsules (5 × 9 mm). If necessary, several conspecifics would be pooled into a capsule to meet the minimum weight required for stable isotope analysis (i.e., 2 mg in this study). The number of isotope capsules for each species generally mirrored the arthropod community composition in the field. Stable isotope analysis (352 arthropod predator and 828 prey isotope samples) was conducted at the UC Davis Stable Isotope Facility using a PDZ Europa ANCA-GSL elemental analyzer interfaced to a PDZ Europa 20-20 isotope ratio mass spectrometer (Sercon Ltd., Cheshire, UK). The standards for carbon and nitrogen stable isotope ratios were Vienna PeeDee Beleminte and atmospheric N_2, respectively. The results of our samples were expressed in per mil (‰) relative to the international standards ($\delta^{13}C$ and $\delta^{15}N$).

2.3. Arthropod trophic guild assignment

A trophic guild represents a group of species using similar resources and forms a basic component of food webs. The concept has been proved to be practical in current ecology because it condenses broad taxonomic information into distinct functional groups in communities (Blondel 2003). In this study, we classified arthropod samples into four trophic guilds (one predator and three prey guilds): 1) "Predators" consisted of spiders and ladybeetles, which are the primary GAPs in rice farms. 2) "Rice herbivores" consisted of major rice pests, including planthoppers, leafhoppers, and stink bugs. 3) "Tourist herbivores" consisted of herbivorous species without direct trophic association with rice plants, including some grasshoppers and leaf beetles. 4) "Detritivores" consisted of arthropods that feed on decaying organic material or plankton, including various midge and fly species. The classification of prey guilds was based on a combination of literature surveys and k-means clustering of stable isotope signatures of arthropod samples (see Appendix A: Fig. S1 for a stable isotope biplot for the three prey sources). The arthropod families/genera in each trophic guild are detailed in Appendix A: Table S1. This study focused on the trophic interactions between generalist predators and their prey sources and therefore did not consider less abundant trophic guilds (e.g., parasitoids) in subsequent analyses.

2.4. Data analyses

To quantify the diet composition of predators, we constructed Bayesian stable isotope mixing models using the R MixSIAR package (Stock et al. 2018) to estimate the proportions of different prey sources (i.e., the three prey guilds including rice herbivores, tourist herbivores, and detritivores) in predators' diet. The Bayesian framework allows for the incorporation of prior information on the diets of predators as well as various sources of uncertainty in the diet estimation (Moore & Semmens 2008; Parnell et al. 2013). In the mixing models, individual farm-year combination and crop stage were included as fixed effects for predator isotope data; isotope data for the three prey guilds were pooled respectively to generate fixed source values because of their high mobility across farms (Mazzi & Dorn 2012; Sun et al. 2015). Isotope data at the seedling stage for the three study years were omitted from the mixing model analysis due to insufficient sample sizes for reliable model estimation of predators' diet composition. To improve our model estimates, we incorporated carbon and nitrogen concentration dependencies (C and N contents of the isotope samples) as well as the residual/process errors (Phillips & Koch 2002; Stock & Semmens 2016). Trophic discrimination factors (TDFs) were estimated from the diet-dependent discrimination equation proposed by Caut, Angulo and Courchamp (2009). We ran three Markov Chain Monte Carlo (MCMC) chains, each with 50,000 iterations and a burn-in number of 25,000, along with a non-informative Dirichlet prior (Stock et al. 2018). Chain convergence was assessed via Gelman-Rubin and Geweke diagnostics (Gelman & Rubin 1992). Bayesian posterior median estimates of diet composition (for each year-farm-stage combination) were extracted for further analyses. Bayesian posterior means, SDs, medians, and 95% credible intervals are provided in Appendix B.

To examine how local abiotic and biotic factors may affect the pest consumption by GAPs over the years of our study, we fit weighted generalized linear mixed models (GLMMs) with a beta distribution and a logit link function using the R glmmTMB package (Brooks *et al.*, 2017), with year, farm type, crop stage, percent forest cover, and the relative abundance of rice herbivores as fixed effects, farm ID nested within pair ID as a random effect, and the proportion of rice herbivores consumed in predators' diet as the response (i.e., posterior medians from the Bayesian stable isotope mixing models). Weights were computed based on the number of diet estimates in each year. Model parameters were estimated using maximum likelihood, and their significance was analyzed via Wald chi-square test using the "Anova" function in the R car package (Fox & Weisberg 2018). Tukey's post-hoc tests ($\alpha = 0.05$) were performed for the significant factors using the "cld" function in the R emmeans package (Length, 2018). The percent forest cover around each study farm was estimated from Google Earth images by manually delimiting the forested areas within a 1-km radius circular buffer surrounding the farm and computing the fraction of these areas in the buffer zone (Appendix A: Table S4). The 1-km radius was based on previous studies (Rusch et al., 2016; Karp *et al.*, 2018). Because spiders and ladybeetles may have different feeding behavior and preference, we also performed all the aforementioned analyses separately for each of the two predator groups. All analyses were conducted in R version 4.0.3 (R Core Team 2021). This study was not specifically designed to survey predator and pest (rice herbivore) abundance, as this would require greater sampling efforts to include diverse and less common species. However, a preliminary analysis of predator and pest abundance is provided in Appendix A: Table S5.

2.5. Replication statement

Scale of inference	**Scale at which the factor of interest is applied**	**Number of replicates at the appropriate scale**
Predator and prey stable isotope analysis & mixing model analysis for predators' diet composition	Predator, rice herbivore, tourist herbivore, and detritivore individuals collected at each rice stage in organic and conventional farms over three study years	352 predator stable isotope samples (capsules) 828 prey stable isotope samples (capsules)
Patterns of pest consumption by predators in rice agro-ecosystems	Proportion of rice herbivores (pests) in predators' diet at each rice stage in organic and conventional farms over three study years	Year 1: 3 crop stages × 6 farms Year 2: 3 crop stages × 14 farms Year 3: 3 crop stages × 14 farms

2.6. Ethics statement

Ethical approval was not required for this study.

3. Results

3.1. Diet composition of predators in rice farms

Across organic and conventional rice farms during 2017-2019, the proportion of rice herbivores in predators' diet increased over the course of the crop season from 21-47% at the tillering stage to 80-97% at the ripening stage; the proportion of detritivores in predators' diet decreased from 35-61% at the tillering stage to <1% at the ripening stage; the proportion of tourist herbivores in predators' diet also decreased from 13-20% at the tillering stage to 3-18% at the ripening stage (Fig. 2a; Appendix A: Table S2, Fig. S2).

Regarding individual predator groups, spiders and ladybeetles showed a marked difference in their diet composition over crop stages during 2017-2019. Across organic and conventional farms, spiders consumed a higher proportion of detritivores (31-55%) in their diet in the beginning of crop season (tillering stage) and substantially increased the consumption on rice herbivores to 78-95% in late crop season (ripening stage) (Fig. 2b; Appendix A: Table S2, Fig. S2). In contrast, ladybeetles in both organic and conventional farms consumed a low proportion of detritivores (≤ 8%) and a steadily high proportion of rice herbivores (≥ 80%) in their diet throughout the crop season (Fig. 2c; Appendix A: Table S2, Fig. S2). Tourist herbivores generally did not constitute an important prey source and contributed less than 33% to the diet of spiders and ladybeetles (Fig. 2b, 2c; Appendix A: Table S2, Fig. S2).

3.2. Patterns of rice herbivore consumption by predators

We further analyzed rice herbivore consumption by GAPs since these herbivores are the primary pests of concern. The patterns of rice herbivore consumption by both predators in organic and conventional rice farms were generally similar across the three study years:

Consumption increased and reached a high proportion during the late crop stages, indicating consistency in the feeding habits of GAPs (Fig. 3). Interestingly, spiders and ladybeetles exhibited distinct within-season patterns of rice herbivore consumption. For spiders in organic and conventional farms, the proportion of rice herbivores in their diet increased toward later crop season, ranging from 17-48% (tillering) to 78-95% (ripening) (Fig. 3b; Appendix A: Table S2, Fig. S2), whereas for ladybeetles in organic and conventional farms, the proportion of rice herbivores in their diet remained relatively stable throughout the season, ranging from 80-93% (tillering) to 97-98% (ripening) (Fig. 3c; Appendix A: Table S2, Fig. S2).

3.3. Factors associated with rice herbivore consumption by predators

The proportion of rice herbivores in GAPs' diet differed between organic and conventional farms for both predators (χ^2 = 7.92, P = 0.01) and spiders (χ^2 = 4.93, P = 0.03), but not ladybeetles (χ^2 = 0.47, P = 0.49; Table 1). Specifically, both predators consumed a higher proportion of rice herbivores in their diet in conventional vs. organic farms (Table 2). The proportion of rice herbivores in GAPs' diet also differed among crop stages (both predators: χ^2 = 249.84, P < 0.001; spiders: χ^2 = 119.01, P < 0.001; ladybeetles: χ^2 = 184.32, P < 0.001; Table 1). Specifically, GAPs consumed higher proportions of rice herbivores in their diet at the flowering and/or ripening stage vs. the tillering stage (Table 3).

The proportion of rice herbivores consumed in GAPs' diet was not associated with the percent forest cover within a 1-km radius buffer surrounding the study farms (both predators: χ^2 = 0.06, P = 0.80; spiders: χ^2 = 0.12, P = 0.73; ladybeetles: χ^2 = 0.34, P = 0.56; Table 1). Furthermore, the proportion of rice herbivores consumed was not associated with the relative abundance of rice herbivores in the field (both predators: $\chi^2 = 0.56$, $P = 0.46$; spiders: $\chi^2 = 0.58$, $P = 0.45$; ladybeetles: $\chi^2 = 0.38$, $P = 0.54$; Fig. 4; Table 1).

4. Discussion

In response to the growing global demand for environmentally friendly agricultural practices that support both biodiversity and food production (Rader et al. 2024), we investigated the potential of GAPs (ubiquitous in nature) as biocontrol agents in rice agro-ecosystems. Specifically, we used stable isotopes to quantify the diet composition of GAPs in organic and conventional rice farms during the crop season in three consecutive years. Our main results include the following: 1) Across the three study years, the rice herbivore consumption by GAPs increased in both organic and conventional farms over the crop season, from 20-47% at the tillering stage to 80-97% at the ripening stage. The high percentage at the ripening stage indicates that GAPs could function as pest specialists during critical growth (late crop) stages. Notably, rice herbivore consumption by spiders increased gradually toward the later crop season, whereas the consumption by ladybeetles remained stable throughout the season. 2) Our results revealed similar among-year patterns in rice herbivore consumption by GAPs in organic and conventional rice farms, suggesting a consistency in GAPs' feeding habits and biocontrol value. 3) The proportion of rice herbivores in GAPs' diets varied with farm type and crop stage (e.g., higher in conventional farms and during flowering/ripening stages). However, contrary to results from previous studies, pest consumption by GAPs was not associated with percent forest cover or the relative abundance of rice herbivores in the field. We discuss in the following: 1) GAPs function as pest specialists at late crop stages, 2) GAPs exhibit consistent pest consumption patterns over years, 3) factors associated with pest consumption by GAPs, and 4) the potential caveats of this study (e.g., pest suppression and intraguild predation). We finish by highlighting the implications of our results for agricultural management.

4.1. Generalist predators function as pest specialists at late crop stages

While biocontrol, a farming practice with a long history, offers a promising solution for sustainable agriculture, the use of GAPs as biocontrol agents remains a concern because GAPs may switch diets between pests and alternative prey (Albajes & Alomar 1999; Prasad & Snyder 2006; Roubinet et al. 2018). This study addressed this concern and revealed a consistency in high pest consumption by GAPs at late crop stages over years. The results provide not only strong support for using GAPs in sustainable pest management, but also a novel aspect in biocontrol—generalist predators may function as guild-level specialist predators of pests during the late crop season. Specifically, across the three study years, GAPs in both organic and conventional farms consumed an increasing proportion of rice herbivores over the crop season, reaching 80-97% in predators' diet at the ripening stage, whereas the proportions of alternative prey (detritivores and tourist herbivores) in their diet gradually decreased below 18% at the ripening stage (Fig. 2; Appendix A: Table S2, Fig. S2). The increase in rice herbivore consumption over time suggests that the biocontrol potential of predators increases toward late crop stages and peaks at the critical stage of crop production. This could be because of a higher herbivore (pest) density at late crop stages, suggested by a correlation between rice herbivore consumption and crop stage (see *Factors associated with pest consumption by predators*).

While GAPs consumed a high proportion of pests at late crop stages, the two major predator groups in our study system, spiders and ladybeetles (Table S1), exhibited distinct dietary patterns over the crop season. Specifically, pest consumption by spiders increased substantially, but pest consumption by ladybeetles remained stable over the season (Fig. 3b vs. 3c). This may be because different foraging modes—sit-and-wait (spiders) or actively hunting (ladybeetles)—can lead to different prey capture and thus diet composition (Klecka & Boukal 2013; Nyffeler 1999). For example, long-jawed orb-weavers (*Tetragnatha*), the most abundant genus in our spider samples, are sit-and-wait predators. The diet composition of these predators generally reflects prey availability (Nyffeler 1999). In contrast, ladybeetles are actively hunting predators and may preferentially feed on rice herbivores, resulting in stable pest consumption over time. Because predator foraging modes shape predator-prey-plant interactions (Schmitz 2008), we encourage future studies to examine different assemblages of sit-and-wait vs. actively hunting predators in field conditions to reveal the most efficient biocontrol practice over the entire crop season.

4.2. Generalists exhibit consistent pest consumption patterns over years

Ideal biocontrol agents provide a consistent, predictable effect on pests under various environmental conditions. Accordingly, GAPs in this study showed consistent pest consumption across years, despite various abiotic and biotic environmental conditions. Specifically, regarding the abiotic factors, the daily mean temperature, particularly from April to June, varied substantially among years (Appendix A: Fig. S3). The daily precipitation also fluctuated over the three study years, with multiple high precipitation events in 2017, overall low precipitation in 2018, and relatively uniform precipitation in 2019 (Appendix A: Fig. S3). Regarding the biotic factors, the composition of rice herbivores at the flowering and ripening stages differed substantially among the three years, in particular the two most dominant groups: leafhoppers (Cicadellidae/*Nephotettix*) and planthoppers (Delphacidae/*Nilaparvata*) (Appendix A: Table S3).

Although both abiotic and biotic factors varied substantially over the years of our study, pest consumption by GAPs generally remained stable, suggesting that GAPs can be a predictable, valuable tool for pest control in rice fields (but see Eitzinger et al. 2021).

4.3. Factors associated with pest consumption by predators

The proportion of rice pests in GAPs' diets differed between farm types and among crop stages but was not associated with the percent forest cover surrounding the farms or the relative abundance of rice herbivores in the field. Overall, GAPs in conventional farms consumed a higher proportion of rice pests in their diet compared to those in organic farms. There are two explanations for this: 1) Organic farming may promote arthropod diversity and therefore distract predators from feeding on target pests (Bengtsson, Ahnström & WEIBULL 2005; Birkhofer, Wise & Scheu 2008; Lichtenberg et al. 2017). 2) Pest densities may be higher in conventional farms (Porcel et al. 2018), leading to higher predator-prey encounter rates and thus pest consumption by GAPs. Regardless of the potential mechanisms, our results highlight the important but overlooked biocontrol value of GAPs in conventional farming systems. On the other hand, GAPs remain crucial for pest management in organic farms, particularly in the absence of pesticides. We encourage future studies to investigate their biocontrol effectiveness and interactions with other natural enemies in organic systems.

Besides farming practices, crop stages also affected pest consumption. Overall, pest consumption by GAPs increased from early (tillering) to late (ripening) stages, consistent with previous studies where predators consumed more pests in the late crop season (Hsu, Ou & Ho 2021; Roubinet et al. 2017). This may be because pest populations increased with rice development and eventually predominated, leading to high pest consumption by GAPs at the flowering and ripening stages. These findings indicate a higher biocontrol value of predators when the crop production is most vulnerable to pest damage. Therefore, farming practitioners may want to avoid practices that harm predators (e.g., chemical applications) during this period to maintain healthy predator populations, preserve predator biodiversity, and sustain the ecosystem services they provide.

Complex habitat structure (e.g., surrounding vegetation) has been suggested to promote predator abundance and diversity (Diehl et al. 2013; Langellotto & Denno 2004), but such higher complexity did not affect predators' diet composition in our study. This might be because the prey species in our study system were mostly associated with rice plants but not the surrounding vegetation, consistent with a meta-analysis where habitat complexity had no effect on crop herbivore densities (Langellotto & Denno 2004). Note that surrounding vegetation (e.g., cropping system mosaic) may still influence pest control efficacy by affecting the population dynamics and persistence of predators and prey (Vasseur et al. 2013). Furthermore, although the diet composition of generalist predators may correlate with prey availability in the field (Hsu, Ou & Ho 2021; Wise, Moldenhauer & Halaj 2006), our beta regression models suggest no such correlation between rice herbivores and GAPs. An explanation is that the relative abundance of rice herbivores was highly correlated with crop stage, a significant factor likely associated with various covariates (e.g., rice plant height) and explaining most variations in pest consumption by GAPs. We encourage further experiments, both observational and manipulative, to clarify the link between prey availability and generalist predators' diet composition in the field.

4.4. Potential caveats of this study

Our study demonstrates high pest consumption by GAPs in rice fields over three years and examines the factors influencing GAPs' diet composition. While our study provides evidence for GAPs' biocontrol potential, some caveats may exist. First, high pest consumption in GAPs' diets does not necessarily imply a strong suppression of pest populations in the field, since pest population dynamics depend not only on the per capita effect of predators but also predator density and diversity (Letourneau et al. 2009; Rusch et al. 2016). To unveil the connection between per capita pest consumption and overall pest dynamics, future work may require complementing stable isotope analysis with field experiments (e.g., manipulating predator density), along with assessments of crop damage and production, to better understand the overall effect of GAPs on pest control and crop performance.

Second, while intraguild predation potentially influences the pest control by GAPs (Michalko, Pekár & Entling 2019; Straub, Finke & Snyder 2008), it was not quantified in our diet composition analysis. Intraguild predation can compromise pest control by predators. For example, hunting spiders in apple orchards exhibit high levels of intraguild predation, thereby reducing pest control (Hambäck et al. 2021; Mezőfi et al. 2020). We did not quantify intraguild predation in our diet composition analysis because we were unable to accurately distinguish predator individuals engaging in intraguild predation from those that did not in the stable isotope mixing models. However, this may not be a major concern in our study because of the following reasons: 1) Rice plants grow in dense clumps, especially at late crop stages (Fig. 1b), forming a complex structure that likely reduces intraguild predation pressure (Finke & Denno 2006; Janssen et al. 2007); 2) The primary spider families in our study were web-building sit-and-wait predators, which are less prone to intraguild predation (Denno et al. 2004); 3) The $\delta^{15}N$ values of predators were close to those of rice herbivores (Fig. S1), suggesting that if intraguild predation occurred, it was likely minor; otherwise, predators' $\delta^{15}N$ values would be higher. Nevertheless, we caution that our diet estimates of predators (without predator-predator interference) might not apply to systems where intraguild predation prevails.

Third, the trophic discrimination factors (TDFs) used to calculate diet composition in this study were derived from general equations by Caut *et al.* (2009) rather than from feeding experiments, which were not feasible given our field study's diverse prey and generalist predator system. Nonetheless, we validated our results using other published TDFs relevant to our study taxa and found consistent outcomes, revealing the robustness of our findings to variations in TDF values (Appendix C).

5. Conclusions

While biocontrol has been recognized as a valuable tool for sustainable agriculture, whether generalist predators can serve as effective biocontrol agents in pest management remains unclear. Our study helps solve this long-standing puzzle by using stable isotope analysis to quantify the diet composition of GAPs (spiders and ladybeetles) over the rice growth season and identifying the underlying mechanisms for enemy-pest interactions in rice farms over three consecutive years. The results show a high proportion of rice pests in GAPs' diets in both organic and conventional rice farms (e.g., 80-97% at the ripening stage), suggesting that these generalist predators function as "pest specialists" at late crop stages (when rice plants are fruiting and pests are abundant). The high pest consumption remained consistent across years regardless of abiotic and biotic conditions, demonstrating the potential that generalist predators may produce a stable, predictable top-down effect on pests. Overall, our study lends support to applying generalist predators as biocontrol agents in both organic and conventional rice farms.

As sustainable agriculture has become more important than ever in human history, incorporating the ubiquitous generalist predators into pest management, such as maintaining healthy populations of these predators, will likely open a promising avenue towards this goal.

Appendix A, B, and C. Supporting information

Supplementary information associated with this article can be found in the online version at doi:xxx.

References

Albajes, R. & Alomar, Ò. (1999) Current and potential use of polyphagous predators. *Integrated pest and disease management in greenhouse crops*, pp. 265-275. Springer.

Albertini, A., Marchi, S., Ratti, C., Burgio, G., Petacchi, R. & Magagnoli, S. (2018) Bactrocera oleae pupae predation by Ocypus olens detected by molecular gut content analysis. *BioControl,* 63, 227-239.

Altieri, M.A. (1999) The ecological role of biodiversity in agroecosystems. *Invertebrate biodiversity as bioindicators of sustainable landscapes*, pp. 19-31. Elsevier.

Altieri, M.A. & Letourneau, D.K. (1982) Vegetation management and biological control in agroecosystems. *Crop Protection,* 1, 405-430.

Baker, B.P., Green, T.A. & Loker, A.J. (2020) Biological control and integrated pest management in organic and conventional systems. *Biological Control,* 140.

Barbosa, P. & Castellanos, I. (2005) *Ecology of predator-prey interactions*. Oxford University Press.

Bengtsson, J., Ahnström, J. & WEIBULL, A.C. (2005) The effects of organic agriculture on biodiversity and abundance: a meta-analysis. *Journal of Applied Ecology,* 42, 261-269.

Birkhofer, K., Fließbach, A., Wise, D.H. & Scheu, S. (2011) Arthropod food webs in organic and conventional wheat farming systems of an agricultural long-term experiment: a stable isotope approach. *Agricultural and Forest Entomology,* 13, 197-204.

Birkhofer, K., Wise, D.H. & Scheu, S. (2008) Subsidy from the detrital food web, but not microhabitat complexity, affects the role of generalist predators in an aboveground herbivore food web. *Oikos,* 117, 494-500.

Blondel, J. (2003) Guilds or functional groups: does it matter? *Oikos,* 100, 223-231.

Boecklen, W.J., Yarnes, C.T., Cook, B.A. & James, A.C. (2011) On the use of stable isotopes in trophic ecology. *Annual review of ecology, evolution, and systematics,* 42, 411-440.

Campbell, B.M., Beare, D.J., Bennett, E.M., Hall-Spencer, J.M., Ingram, J.S., Jaramillo, F., . . . Shindell, D. (2017) Agriculture production as a major driver of the Earth system exceeding planetary boundaries. *Ecology and Society,* 22.

Caut, S., Angulo, E. & Courchamp, F. (2009) Variation in discrimination factors (Δ15N and Δ13C): the effect of diet isotopic values and applications for diet reconstruction. *Journal of Applied Ecology,* 46, 443-453.

Cuff, J.P., Tercel, M.P.T.G., Drake, L.E., Vaughan, I.P., Bell, J.R., Orozco-terWengel, P., . . . Symondson, W.O.C. (2022) Density-independent prey choice, taxonomy, life history, and web characteristics determine the diet and biocontrol potential of spiders (Linyphiidae and Lycosidae) in cereal crops. *Environmental DNA,* 4, 549-564.

Denno, R.F., Mitter, M.S., Langellotto, G.A., Gratton, C. & Finke, D.L. (2004) Interactions between a hunting spider and a web-builder: consequences of intraguild predation and cannibalism for prey suppression. *Ecological Entomology,* 29, 566-577.

Diehl, E., Mader, V.L., Wolters, V. & Birkhofer, K. (2013) Management intensity and vegetation complexity affect web-building spiders and their prey. *Oecologia,* 173, 579-589.

Dominik, C., Seppelt, R., Horgan, F.G., Settele, J. & Václavík, T. (2018) Landscape composition, configuration, and trophic interactions shape arthropod communities in rice agroecosystems. *Journal of applied ecology,* 55, 2461-2472.

Eitzinger, B., Abrego, N., Gravel, D., Huotari, T., Vesterinen, E.J. & Roslin, T. (2019) Assessing changes in arthropod predator–prey interactions through DNA-based gut content analysis—variable environment, stable diet. *Molecular ecology,* 28, 266-280.

Eitzinger, B., Roslin, T., Vesterinen, E.J., Robinson, S.I. & O'Gorman, E.J. (2021) Temperature affects both the Grinnellian and Eltonian dimensions of ecological niches–A tale of two Arctic wolf spiders. *Basic and Applied Ecology,* 50, 132-143.

Eitzinger, B. & Traugott, M. (2011) Which prey sustains cold-adapted invertebrate generalist predators in arable land? Examining prey choices by molecular gut-content analysis. *Journal of Applied Ecology,* 48, 591-599.

European Commission (2020) Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions: a farm to fork strategy for a fair, healthy and environmentally-friendly food system COM/2020/381 final.

Finke, D.L. & Denno, R.F. (2006) Spatial refuge from intraguild predation: implications for prey suppression and trophic cascades. *Oecologia,* 149, 265-275.

Fox, J. & Weisberg, S. (2018) *An R companion to applied regression*. Sage publications.

Gajski, D., Mifková, T., Košulič, O., Michálek, O., Serbina, L.Š., Michalko, R. & Pekár, S. (2023) Brace yourselves, winter is coming: the winter activity, natural diet, and prey preference of winter-active spiders on pear trees. *Journal of Pest Science,* , 1-14.

Geiger, F., Bengtsson, J., Berendse, F., Weisser, W.W., Emmerson, M., Morales, M.B., . . . Winqvist, C. (2010) Persistent negative effects of pesticides on biodiversity and biological control potential on European farmland. *Basic and Applied Ecology,* 11, 97-105.

Gelman, A. & Rubin, D.B. (1992) Inference from iterative simulation using multiple sequences. *Statistical science,* 7, 457-472.

Gomiero, T., Pimentel, D. & Paoletti, M.G. (2011) Is there a need for a more sustainable agriculture? *Critical reviews in plant sciences,* 30, 6-23.

Hambäck, P.A., Cirtwill, A.R., García, D., Grudzinska-Sterno, M., Miñarro, M., Tasin, M., . . . Samnegård, U. (2021) More intraguild prey than pest species in arachnid diets may compromise biological control in apple orchards. *Basic and Applied Ecology,* 57, 1-13.

Hsu, G.-C., Ou, J.-A. & Ho, C.-K. (2021) Pest consumption by generalist arthropod predators increases with crop stage in both organic and conventional farms. *Ecosphere,* 12, e03625.

Huang, H.T. & Yang, P. (1987) The ancient cultured citrus ant. *Bioscience,* 37, 665-671.

Ingrao, A.J., Schmidt, J., Jubenville, J., Grode, A., Komondy, L., VanderZee, D. & Szendrei, Z. (2017) Biocontrol on the edge: Field margin habitats in asparagus fields influence natural enemy-pest interactions. *Agriculture, Ecosystems & Environment,* 243, 47-54.

Janssen, A., Sabelis, M.W., Magalhães, S., Montserrat, M. & Van der Hammen, T. (2007) Habitat structure affects intraguild predation. *Ecology,* 88, 2713-2719.

Kehoe, L., Romero-Muñoz, A., Polaina, E., Estes, L., Kreft, H. & Kuemmerle, T. (2017) Biodiversity at risk under future cropland expansion and intensification. *Nature Ecology & Evolution,* 1, 1129-1135.

Klecka, J. & Boukal, D.S. (2013) Foraging and vulnerability traits modify predator–prey body mass allometry: freshwater macroinvertebrates as a case study. *Journal of Animal Ecology,* 82, 1031-1041.

Krey, K.L., Blubaugh, C.K., Chapman, E.G., Lynch, C.A., Snyder, G.B., Jensen, A.S., . . . Snyder, W.E. (2017) Generalist predators consume spider mites despite the presence of alternative prey. *Biological Control,* 115, 157-164.

Kuusk, A.-K. & Ekbom, B. (2012) Feeding habits of lycosid spiders in field habitats. *Journal of Pest Science,* 85, 253-260.

Langellotto, G.A. & Denno, R.F. (2004) Responses of invertebrate natural enemies to complex-structured habitats: a meta-analytical synthesis. *Oecologia,* 139, 1-10.

Layman, C.A., Araujo, M.S., Boucek, R., Hammerschlag-Peyer, C.M., Harrison, E., Jud, Z.R., . . . Yeager, L.A. (2012) Applying stable isotopes to examine food-web structure: an overview of analytical tools. *Biological Reviews,* 87, 545-562.

Letourneau, D.K., Jedlicka, J.A., Bothwell, S.G. & Moreno, C.R. (2009) Effects of natural enemy biodiversity on the suppression of arthropod herbivores in terrestrial ecosystems. *Annual Review of Ecology Evolution and Systematics,* 40, 573-592.

Lichtenberg, E.M., Kennedy, C.M., Kremen, C., Batary, P., Berendse, F., Bommarco, R., . . . Williams, N.M. (2017) A global synthesis of the effects of diversified farming systems on arthropod diversity within fields and across agricultural landscapes. *Global change biology,* 23, 4946-4957.

Mazzi, D. & Dorn, S. (2012) Movement of insect pests in agricultural landscapes. *Annals of applied biology,* 160, 97-113.

Mezőfi, L., Markó, G., Nagy, C., Korányi, D. & Markó, V. (2020) Beyond polyphagy and opportunism: natural prey of hunting spiders in the canopy of apple trees. *Peerj,* 8.

Michalko, R., Pekár, S. & Entling, M.H. (2019) An updated perspective on spiders as generalist predators in biological control. *Oecologia,* 189, 21-36.

Moore, J.W. & Semmens, B.X. (2008) Incorporating uncertainty and prior information into stable isotope mixing models. *Ecology Letters,* 11, 470-480.

Morente, M. & Ruano, F. (2022) Understanding the trophic relationships amongst arthropods in olive grove by δN15 and δC13 stable isotope analysis. *Journal of Applied Entomology,* 146, 372-384.

Newton, J. (2016) Stable isotopes as tools in ecological research. *eLS*, 1-8.

Nyffeler, M. (1999) Prey selection of spiders in the field. *Journal of Arachnology*, 317-324.

Otieno, N.E., Butler, M. & Pryke, J.S. (2023) Fallow fields and hedgerows mediate enhanced arthropod predation and reduced herbivory on small scale intercropped maize farms–

δ13C and δ15N stable isotope evidence. *Agriculture, Ecosystems & Environment,* 349, 108448.

Parnell, A.C., Phillips, D.L., Bearhop, S., Semmens, B.X., Ward, E.J., Moore, J.W., . . . Inger, R. (2013) Bayesian stable isotope mixing models. *Environmetrics,* 24, 387-399.

Phillips, D.L. & Koch, P.L. (2002) Incorporating concentration dependence in stable isotope mixing models. *Oecologia,* 130, 114-125.

Porcel, M., Andersson, G.K., Pålsson, J. & Tasin, M. (2018) Organic management in apple orchards: higher impacts on biological control than on pollination. *Journal of Applied Ecology,* 55, 2779-2789.

Post, D.M. (2002) Using stable isotopes to estimate trophic position: models, methods, and assumptions. *Ecology,* 83, 703-718.

Power, A.G. (2010) Ecosystem services and agriculture: tradeoffs and synergies. *Philosophical Transactions of the Royal Society B-Biological Sciences,* 365, 2959-2971.

Prasad, R. & Snyder, W. (2006) Polyphagy complicates conservation biological control that targets generalist predators. *Journal of Applied Ecology,* 43, 343-352.

R Core Team (2021) R: A language and environment for statistical computing. *R Foundation for Statistical Computing, Vienna, Austria*.

Rader, R., Nuñez, M.A., Siqueira, T., Zou, Y., Macinnis-Ng, C., Marini, L., . . . Barlow, J. (2024) Beyond yield and toward sustainability: Using applied ecology to support biodiversity conservation and food production. *Journal of Applied Ecology,* 61, 1142-1146.

Roubinet, E., Birkhofer, K., Malsher, G., Staudacher, K., Ekbom, B., Traugott, M. & Jonsson, M. (2017) Diet of generalist predators reflects effects of cropping period and farming system on extra- and intraguild prey. *Ecological Applications,* 27, 1167-1177.

Roubinet, E., Jonsson, T., Malsher, G., Staudacher, K., Traugott, M., Ekbom, B. & Jonsson, M. (2018) High redundancy as well as complementary prey choice characterize generalist predator food webs in agroecosystems. *Scientific Reports,* 8, 1-10.

Rusch, A., Chaplin-Kramer, R., Gardiner, M.M., Hawro, V., Holland, J., Landis, D., . . . Winqvist, C. (2016) Agricultural landscape simplification reduces natural pest control: A quantitative synthesis. *Agriculture, Ecosystems & Environment,* 221, 198-204.

Schmitz, O.J. (2008) Effects of predator hunting mode on grassland ecosystem function. *Science,* 319, 952-954.

Settle, W.H., Ariawan, H., Astuti, E.T., Cahyana, W., Hakim, A.L., Hindayana, D. & Lestari, A.S. (1996) Managing tropical rice pests through conservation of generalist natural enemies and alternative prey. *Ecology,* 77, 1975-1988.

Stiling, P. & Cornelissen, T. (2005) What makes a successful biocontrol agent? A meta-analysis of biological control agent performance. *Biological Control,* 34, 236-246.

Stock, B.C., Jackson, A.L., Ward, E.J., Parnell, A.C., Phillips, D.L. & Semmens, B.X. (2018) Analyzing mixing systems using a new generation of Bayesian tracer mixing models. *Peerj,* 6.

Stock, B.C. & Semmens, B.X. (2016) Unifying error structures in commonly used biotracer mixing models. *Ecology,* 97, 2562-2569.

Straub, C.S., Finke, D.L. & Snyder, W.E. (2008) Are the conservation of natural enemy biodiversity and biological control compatible goals? *Biological Control,* 45, 225-237.

Sun, J.-T., Wang, M.-M., Zhang, Y.-K., Chapuis, M.-P., Jiang, X.-Y., Hu, G., . . . Hong, X.-Y. (2015) Evidence for high dispersal ability and mito-nuclear discordance in the small brown planthopper, Laodelphax striatellus. *Scientific Reports,* 5, 1-10.

Symondson, W., Sunderland, K. & Greenstone, M. (2002) Can generalist predators be effective biocontrol agents? *Annual review of entomology,* 47, 561-594.

Vasseur, C., Joannon, A., Aviron, S., Burel, F., Meynard, J.M. & Baudry, J. (2013) The cropping systems mosaic: How does the hidden heterogeneity of agricultural landscapes drive arthropod populations? *Agriculture Ecosystems & Environment,* 166, 3-14.

Wardle, D.A., Nicholson, K.S., Bonner, K.I. & Yeates, G.W. (1999) Effects of agricultural intensification on soil-associated arthropod population dynamics, community structure, diversity and temporal variability over a seven-year period. *Soil Biology & Biochemistry,* 31, 1691-1706.

Wise, D.H., Moldenhauer, D.M. & Halaj, J. (2006) Using stable isotopes to reveal shifts in prey consumption by generalist predators. *Ecological Applications,* 16, 865-876.

Tables with captions

Table 1. Statistical results from GLMM beta regression models for examining the effects of abiotic and biotic factors on pest consumption by spiders, ladybeetles, and both predators over the years of our study.

Model	Factor	*d.f.*	χ^2	*P*
Both predators	Year	2	8.00	0.02
	Farm type	1	7.29	0.01
	Crop stage	2	249.84	< 0.001
	Percent forest cover	1	0.06	0.80
	Relative abundance of rice herbivores	1	0.56	0.46
Spiders	Year	2	9.30	0.01
	Farm type	1	4.93	0.03
	Crop stage	2	119.01	< 0.001
	Percent forest cover	1	0.12	0.73
	Relative abundance of rice herbivores	1	0.58	0.45
Ladybeetles	Year	2	17.29	< 0.001
	Farm type	1	0.47	0.49
	Crop stage	2	184.32	< 0.001
	Percent forest cover	1	0.34	0.56
	Relative abundance of rice herbivores	1	0.38	0.54

Table 2. Tukey's post-hoc tests comparing the proportion of rice herbivores consumed in the diet of predators in organic and conventional rice farms. Different superscript letters indicate significant differences in the estimated marginal means (EMMs) of the posterior medians from Bayesian stable isotope mixing models ($\alpha = 0.05$).

Model	Farm type	EMMs (± SE)	Lower 2.5%	Upper 2.5%
Both predators	Organic	0.61^{a} (±0.08)	0.45	0.76
	Conventional	0.81^{b} (±0.05)	0.69	0.90
Spiders	Organic	0.55^{a} (±0.10)	0.35	0.73
	Conventional	0.79^{b} (±0.07)	0.63	0.90
Ladybeetles	Organic	0.95^{a} (±0.01)	0.93	0.96
	Conventional	0.95^{a} (±0.01)	0.94	0.96

Table 3. Tukey's post-hoc tests comparing the proportion of rice herbivores consumed in the diet of predators at three crop stages (tillering, flowering, and ripening stages). Different superscript letters indicate significant differences in the estimated marginal means (EMMs) of the posterior medians from Bayesian stable isotope mixing models ($\alpha = 0.05$).

Model	Crop stage	EMMs (± SE)	Lower 2.5%	Upper 2.5%
Both predators	Tillering	0.24^{a} (±0.06)	0.14	0.36
	Flowering	0.85^{b} (±0.04)	0.76	0.91
	Ripening	0.91^{c} (±0.03)	0.85	0.95
Spiders	Tillering	0.27^{a} (±0.07)	0.16	0.43
	Flowering	0.81^{b} (±0.05)	0.69	0.89
	Ripening	0.86^{b} (±0.04)	0.75	0.93
Ladybeetles	Tillering	0.92^{a} (±0.01)	0.89	0.93
	Flowering	0.92^{a} (±0.01)	0.90	0.93
	Ripening	0.98^{b} (±0.01)	0.98	0.99

Figures

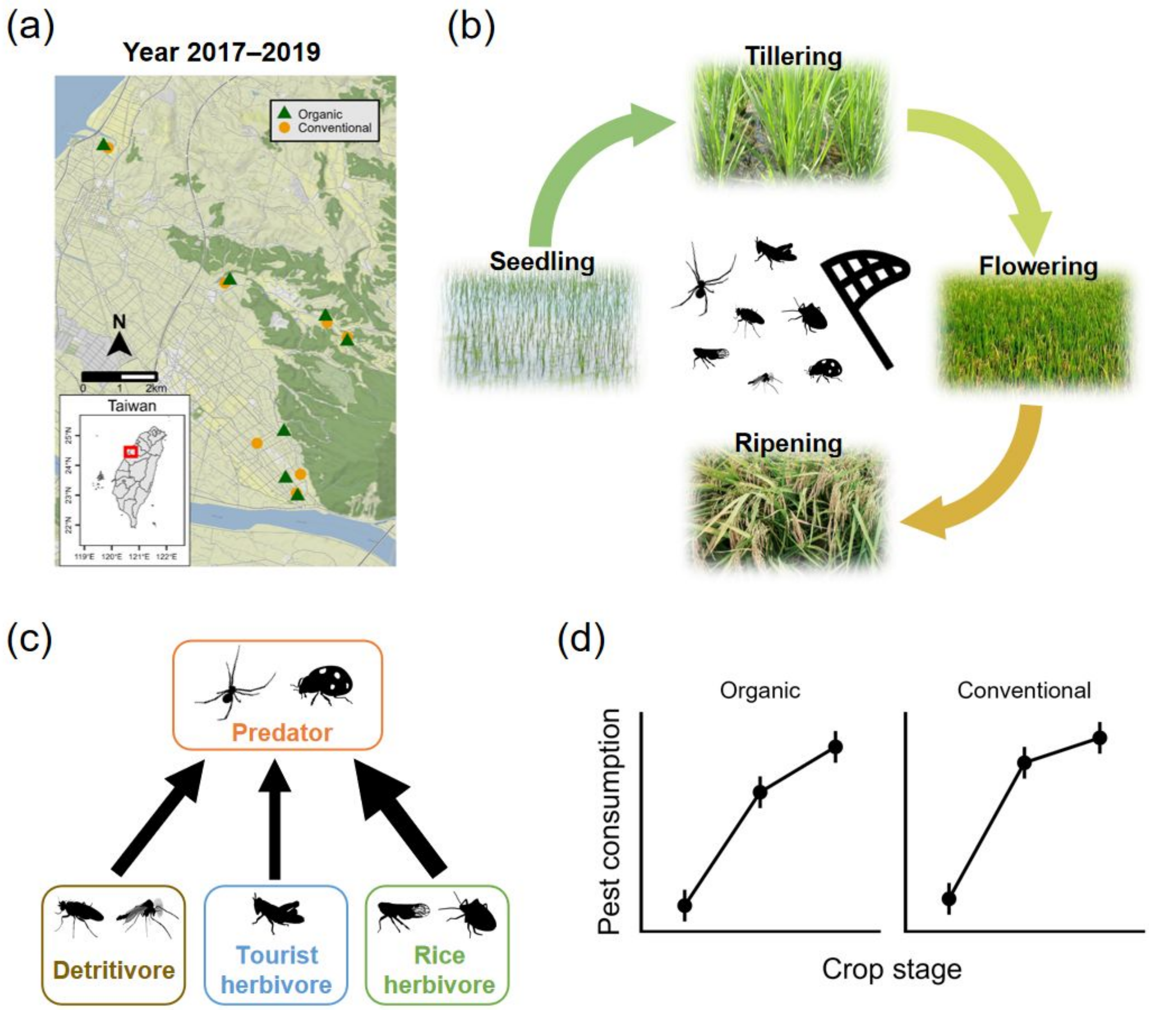
Figure 1. Sampling design and analyses of the study: (a) Map of the paired organic and conventional rice farms across the three study years (three farm pairs in 2017 and seven farm pairs each in 2018 and 2019). The red rectangle in the inset map indicates the region in central Taiwan where the farms were located. (b) Arthropods were sampled in each rice farm at four major crop stages (seedling, tillering, flowering, and ripening) using the sweep net method. (c) Field arthropod samples were categorized into three prey guilds (rice herbivores, tourist herbivores, and detritivores) and one predator guild. Stable isotope analysis was used to quantify the proportions of these prey sources in predators' diets. (d) The proportion of rice herbivores (pests) consumed by predators, derived from (c), was analyzed to examine how pest consumption by predators varied with farm type, crop stage, percent forest cover, and the relative abundance of rice herbivores in the field over the three study years.

Figure 2. The proportions (mean ± SE) of prey sources (rice herbivores, tourist herbivores, and detritivores) consumed in the diet of (a) both predators, (b) spiders, and (c) ladybeetles in organic and conventional rice farms over crop stages. The proportions were computed from the Bayesian posterior medians of diet estimates in replicate farms over the three study years.

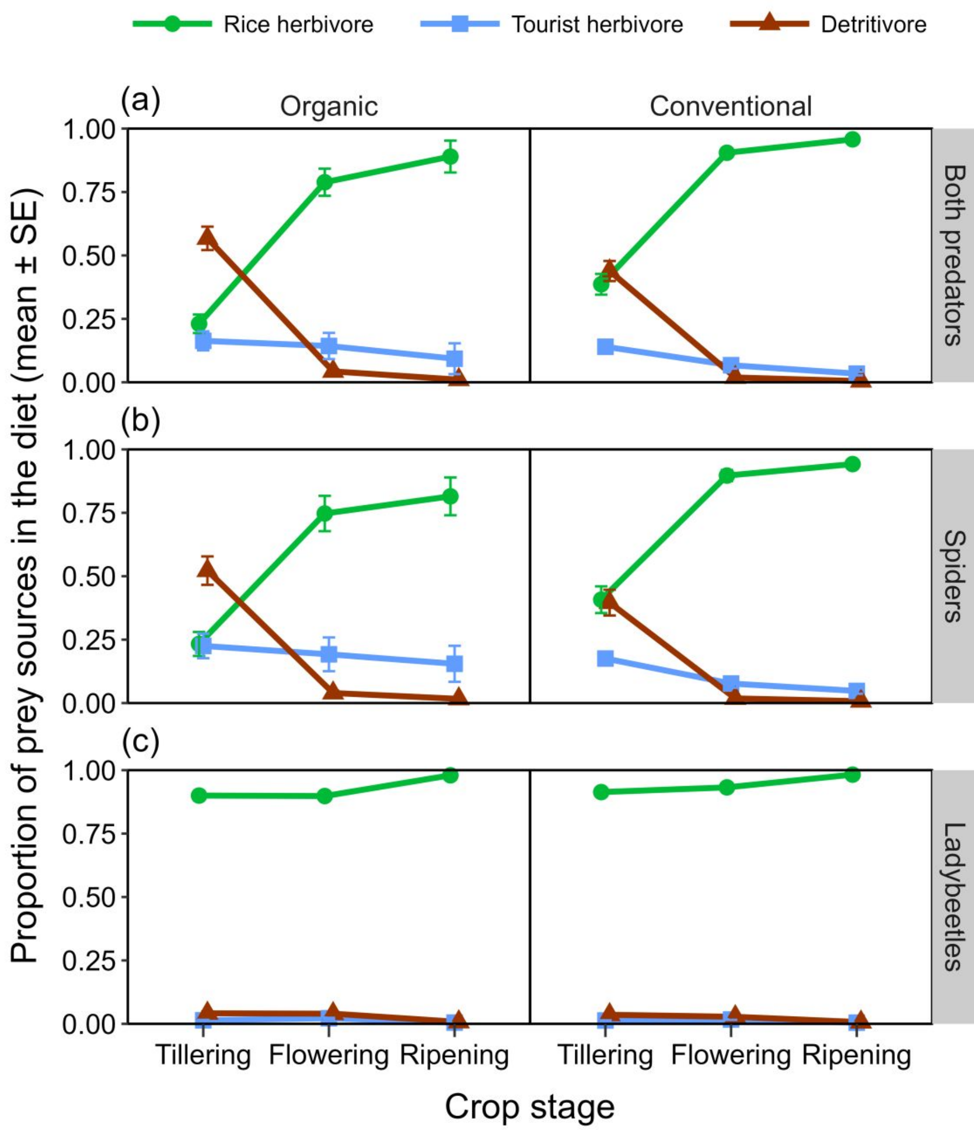
Figure 3. The proportion (mean ± SE) of rice herbivores consumed in the diet of (a) both predators, (b) spiders, and (c) ladybeetles in organic and conventional rice farms over crop stages in the three study years. The proportions were computed from the Bayesian posterior medians of diet estimates in replicate farms.

Figure 4. The relative abundance of prey sources in organic and conventional rice farms over crop stages during the three study years. The relative abundance was determined from the sweep-net samples pooled across replicate farms.

Figure 1.


(a)
Year 2017–2019
Organic
Conventional
N
0 1 2km
Taiwan
(b)
Tillering
Seedling
Flowering
Ripening
(c)
Predator
Detritivore
Tourist herbivore
Rice herbivore
(d)
Organic
Conventional
Pest consumption
Crop stage

671 **Figure 2.**



672

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Figure 3.

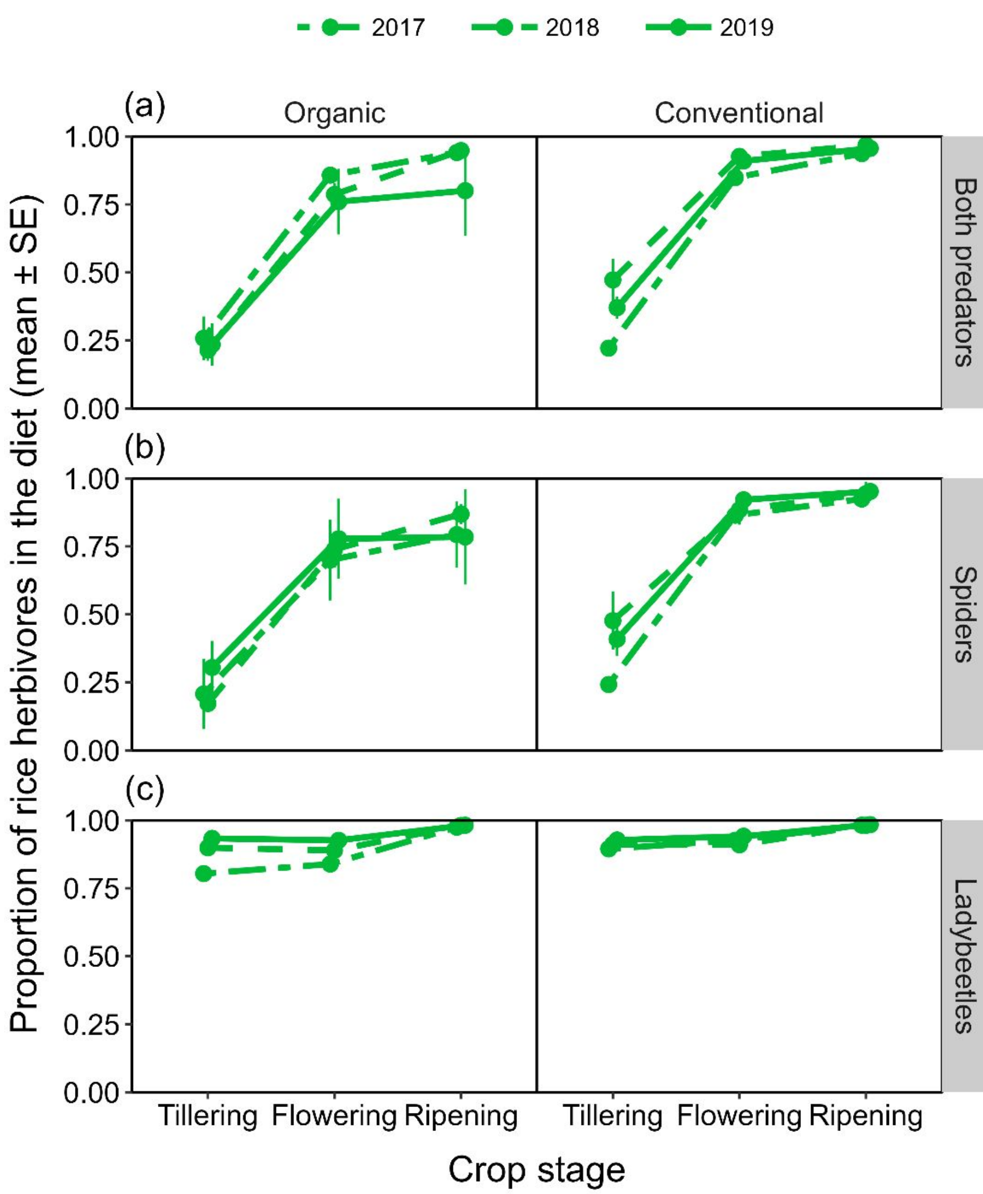
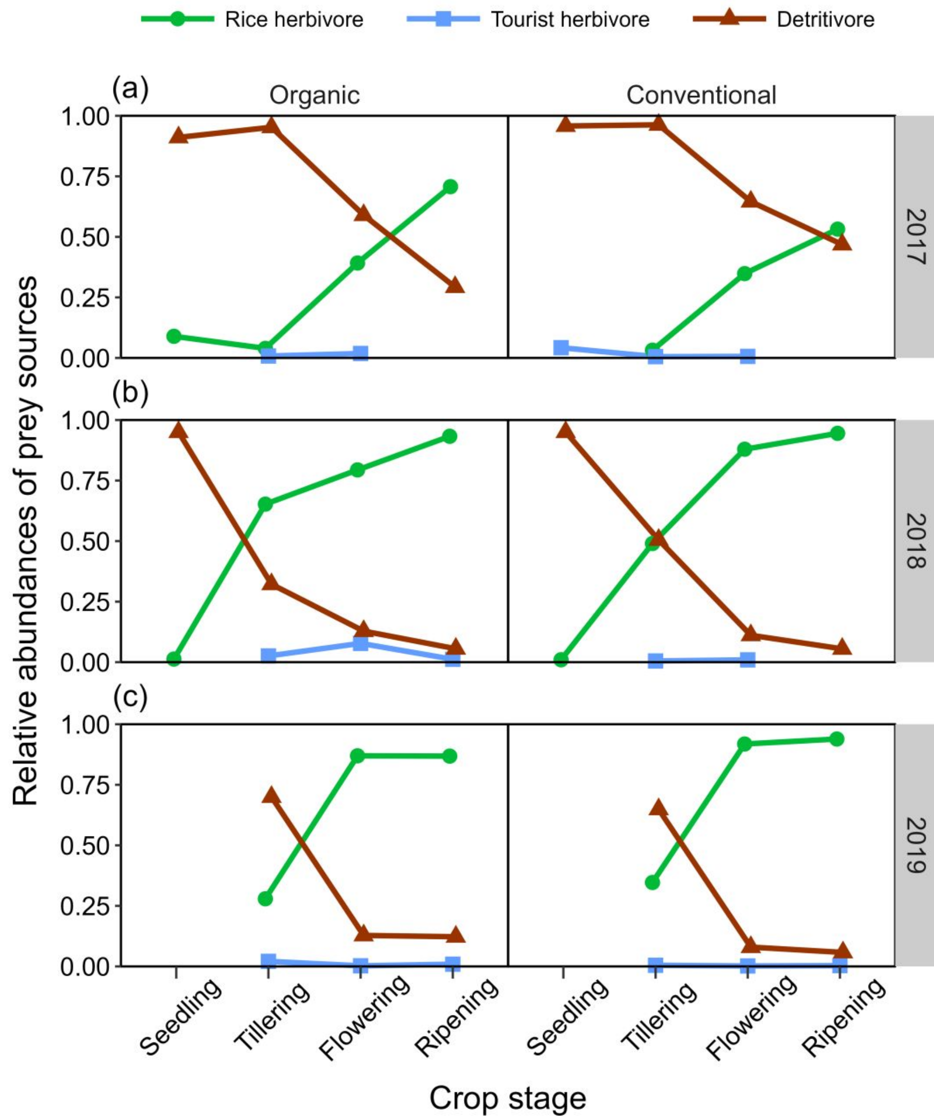

2017
2018
2019
(a)
(b)
(c)
Organic
Conventional
Both predators
Spiders
Ladybeetles
Proportion of rice herbivores in the diet (mean ± SE)
1.00
0.75
0.50
0.25
0.00
Tillering Flowering Ripening
Tillering Flowering Ripening
Crop stage

Figure 4.


Rice herbivore
Tourist herbivore
Detritivore
(a)
Organic
Conventional
2017
(b)
2018
(c)
2019
1.00
0.75
0.50
0.25
0.00
Relative abundances of prey sources
Seedling
Tillering
Flowering
Ripening
Crop stage

Generalist predators function as pest specialists: examining diet composition of spiders and ladybeetles across rice crop stages

Appendix A

4 **Table S1**. Taxonomic composition of trophic guilds and the number of stable isotope capsules
5 prepared for each of the three study years.

6 (a) Year 2017

Trophic guild	Order	Family/Genus	*n* isotope capsules
Predators	Araneae	Araneidae	33
	Araneae	Clubionidae	0
	Araneae	Oxyopidae	0
	Araneae	Tetragnathidae/*Tetragnatha*	24
	Araneae	Thomisidae	0
	Coleoptera	Carabidae	0
	Coleoptera	Coccinellidae	22
Rice herbivores	Hemiptera	Cicadellidae/*Nephotettix*	29
	Hemiptera	Delphacidae/*Nilaparvata*	32
	Hemiptera	Lygaeidae/*Pachybrachius*	10
	Hemiptera	Pentatomidae/*Scotinophara*	37
	Lepidoptera	Hesperiidae	0
	Lepidoptera	Pyralidae	0
	Lepidoptera	Nymphalidae	0
	Orthoptera	Pyrgomorphidae/*Atractomor*	0
Tourist herbivores	Coleoptera	Chrysomelidae	2
	Orthoptera	Acrididae	8
Detritivores	Diptera	Chironomidae	5
	Diptera	Chloropidae	8
	Diptera	Ephydridae	6
	Diptera	Muscidae	3
	Diptera	Sphaeroceridae	0
	Diptera	Stratiomyidae	1
	Diptera	Tephritidae	0

	Orthoptera	Tetrigidae	1

(b) Year 2018

Trophic guild	Order	Family/Genus	*n* isotope capsules
Predators	Araneae	Araneidae	25
	Araneae	Clubionidae	0
	Araneae	Oxyopidae	0
	Araneae	Tetragnathidae/*Tetragnatha*	39
	Araneae	Thomisidae	0
	Coleoptera	Coccinellidae	39
Rice herbivores	Hemiptera	Alydidae/*Leptocorisa*	1
	Hemiptera	Cicadellidae/*Nephotettix*	79
	Hemiptera	Delphacidae/*Nilaparvata*	78
	Hemiptera	Lygaeidae/*Pachybrachius*	2
	Hemiptera	Pentatomidae/*Scotinophara*	33
	Lepidoptera	Hesperiidae	0
	Lepidoptera	Pyralidae	0
	Orthoptera	Pyrgomorphidae/*Atractomor*	0
Tourist herbivores	Coleoptera	Chrysomelidae	3
	Orthoptera	Acrididae	13
Detritivores	Diptera	Chironomidae	13
	Diptera	Chloropidae	4
	Diptera	Ephydridae	7
	Diptera	Empididae	2
	Diptera	Muscidae	26
	Diptera	Sciomyzidae	31
	Diptera	Stratiomyidae	3
	Orthoptera	Tetrigidae	1

(c) Year 2019

Trophic guild	Order	Family/Genus	*n* isotope capsules
Predators	Araneae	Araneidae	68
	Araneae	Clubionidae	0
	Araneae	Oxyopidae	0
	Araneae	Tetragnathidae/*Tetragnatha*	63
	Araneae	Thomisidae	0
	Coleoptera	Coccinellidae	39
Rice herbivores	Diptera	Agromyzidae	0
	Hemiptera	Alydidae/*Leptocorisa*	17
	Hemiptera	Cicadellidae/*Nephotettix*	105
	Hemiptera	Coreidae	0
	Hemiptera	Delphacidae/*Nilaparvata*	82
	Hemiptera	Lygaeidae/*Pachybrachius*	11
	Hemiptera	Miridae	0
	Hemiptera	Pentatomidae/*Scotinophara*	34
	Hemiptera	Ricaniidae	0
	Lepidoptera	Hesperiidae	0
	Lepidoptera	Nymphalidae	0
	Lepidoptera	Pyralidae	0
	Orthoptera	Pyrgomorphidae/*Atractomor*	0
Tourist herbivores	Coleoptera	Chrysomelidae	5
	Orthoptera	Acrididae	13
Detritivores	Diptera	Calliphoridae	0
	Diptera	Chironomidae	29
	Diptera	Chloropidae	27
	Diptera	Ephydridae	28
	Diptera	Lauxaniidae	0

	Diptera	Muscidae	19
	Diptera	Phoridae	0
	Diptera	Platystomatidae	0
	Diptera	Sarcophagidae	0
	Diptera	Sciomyzidae	2
	Diptera	Sphaeroceridae	0
	Diptera	Stratiomyidae	3
	Diptera	Tephritidae	0
	Orthoptera	Tetrigidae	15
	Orthoptera	Tridactylidae	0

Table S2. The proportions (mean ± SE) of prey sources (rice herbivores, tourist herbivores, and detritivores) consumed in predators' diet in organic and conventional rice farms over crop stages in each study year. The mean proportions were computed from the Bayesian posterior medians of diet estimates in replicate farms; *n* represents the number of replicate farms. Note that the differences in *n* within the same study year were due to insufficient predator samples in some replicate farms.

Year	Farm type	Crop stage	Predator	Prey source			*n*
				Rice herbivore	Tourist herbivore	Detritivore	
2017	Organic	Tillering	Both	0.26 ± 0.08	0.15 ± 0.05	0.54 ± 0.13	3
			Spiders	0.21 ± 0.13	0.33 ± 0.17	0.44 ± 0.19	3
			Ladybeetles	0.80	0.02	0.08	1
		Flowering	Both	0.86 ± 0.03	0.09 ± 0.02	0.04 ± 0.02	3
			Spiders	0.70 ± 0.15	0.24 ± 0.16	0.04 ± 0.03	3
			Ladybeetles	0.84	0.03	0.07	1
		Ripening	Both	0.94 ± 0.01	0.04 ± 0.01	0.01 ± 0.01	3
			Spiders	0.79 ± 0.12	0.18 ± 0.12	0.02 ± 0.01	3
			Ladybeetles	0.97 ± 0.01	0.01 ± 0.00	0.01 ± 0.00	3
	Conventional	Tillering	Both	0.22 ± 0.02	0.15 ± 0.05	0.60 ± 0.05	3
			Spiders	0.24 ± 0.01	0.20 ± 0.07	0.55 ± 0.08	3
			Ladybeetles	0.90	0.01	0.04	1
		Flowering	Both	0.85 ± 0.03	0.1 ± 0.03	0.03 ± 0.01	3
			Spiders	0.86 ± 0.02	0.1 ± 0.03	0.03 ± 0.01	3
			Ladybeetles	0.93 ± 0.01	0.02 ± 0.00	0.03 ± 0.00	2
		Ripening	Both	0.94 ± 0.02	0.05 ± 0.02	0.01 ± 0.00	3
			Spiders	0.92 ± 0.02	0.06 ± 0.02	0.01 ± 0.00	3
			Ladybeetles	0.98 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	2
2018	Organic	Tillering	Both	0.21 ± 0.04	0.20 ± 0.07	0.54 ± 0.07	7
			Spiders	0.17 ± 0.03	0.26 ± 0.08	0.54 ± 0.08	7
			Ladybeetles	0.90 ± 0.02	0.01 ± 0.00	0.04 ± 0.01	6
		Flowering	Both	0.79 ± 0.04	0.14 ± 0.04	0.04 ± 0.01	6
			Spiders	0.74 ± 0.07	0.18 ± 0.07	0.04 ± 0.01	5

			Ladybeetles	0.89 ± 0.01	0.02 ± 0.00	0.04 ± 0.01	3
		Ripening	Both	0.95 ± 0.01	0.03 ± 0.01	0.01 ± 0.00	5
			Spiders	0.87 ± 0.04	0.09 ± 0.02	0.02 ± 0.01	4
			Ladybeetles	0.98 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	5
	Conventional	Tillering	Both	0.47 ± 0.08	0.12 ± 0.02	0.35 ± 0.05	7
			Spiders	0.48 ± 0.11	0.18 ± 0.03	0.31 ± 0.08	7
			Ladybeetles	0.91 ± 0.01	0.01 ± 0.00	0.04 ± 0.01	4
		Flowering	Both	0.93 ± 0.03	0.05 ± 0.02	0.01 ± 0.00	6
			Spiders	0.88 ± 0.05	0.09 ± 0.04	0.01 ± 0.01	6
			Ladybeetles	0.91 ± 0.03	0.02 ± 0.00	0.04 ± 0.01	2
		Ripening	Both	0.97 ± 0.01	0.03 ± 0.01	0.00 ± 0.00	7
			Spiders	0.94 ± 0.04	0.05 ± 0.04	0.00 ± 0.00	2
			Ladybeetles	0.98 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	5
2019	Organic	Tillering	Both	0.23 ± 0.08	0.13 ± 0.06	0.61 ± 0.08	7
			Spiders	0.30 ± 0.10	0.14 ± 0.05	0.54 ± 0.09	7
			Ladybeetles	0.93 ± 0.03	0.01 ± 0.00	0.03 ± 0.01	3
		Flowering	Both	0.76 ± 0.12	0.17 ± 0.12	0.05 ± 0.01	7
			Spiders	0.78 ± 0.15	0.18 ± 0.14	0.04 ± 0.01	6
			Ladybeetles	0.93 ± 0.02	0.02 ± 0.00	0.03 ± 0.01	3
		Ripening	Both	0.80 ± 0.17	0.18 ± 0.16	0.01 ± 0.00	5
			Spiders	0.78 ± 0.17	0.19 ± 0.16	0.02 ± 0.01	5
			Ladybeetles	0.98 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	5
	Conventional	Tillering	Both	0.37 ± 0.04	0.15 ± 0.05	0.46 ± 0.06	7
			Spiders	0.41 ± 0.06	0.16 ± 0.05	0.42 ± 0.08	7
			Ladybeetles	0.93 ± 0.00	0.01 ± 0.00	0.03 ± 0.00	2
		Flowering	Both	0.91 ± 0.02	0.06 ± 0.02	0.02 ± 0.00	7
			Spiders	0.92 ± 0.02	0.06 ± 0.02	0.02 ± 0.01	7
			Ladybeetles	0.94 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	6
		Ripening	Both	0.96 ± 0.01	0.04 ± 0.01	0.00 ± 0.00	5
			Spiders	0.95 ± 0.02	0.04 ± 0.02	0.01 ± 0.00	5
			Ladybeetles	0.98 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	3

Table S3. The relative abundance of the major families/genera in rice herbivore guild at the flowering and ripening stages in organic and conventional farms in the three study years. Samples were pooled across replicate farms.

(a) Flowering stage

Family/Genus	Year 2017		Year 2018		Year 2019	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
Cicadellidae/*Nephotettix*	6.70%	8.30%	28.10%	17.70%	63.90%	73.70%
Delphacidae/*Nilaparvata*	84.80%	90.40%	65.50%	77.30%	29.90%	22.10%
Lygaeidae/*Pachybrachius*	NA	NA	1.70%	NA	2.10%	0.80%
Pentatomidae/*Scotinophara*	1%	0.60%	1.70%	4%	1.50%	0.30%
Others	7.60%	0.60%	3%	1.10%	2.50%	3.10%
Total	100%	100%	100%	100%	100%	100%

(b) Ripening stage

Family/Genus	Year 2017		Year 2018		Year 2019	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
Cicadellidae/*Nephotettix*	62.10%	71.70%	72%	78.20%	57%	92.70%
Delphacidae/*Nilaparvata*	34.50%	27.20%	15.30%	11.20%	12.40%	4%
Lygaeidae/*Pachybrachius*	NA	NA	NA	0.50%	15.10%	0.30%
Pentatomidae/*Scotinophara*	3.40%	1.10%	11.40%	9.20%	10.20%	2.50%
Others	NA	NA	1.30%	1%	5.20%	0.60%
Total	100%	100%	100%	100%	100%	100%

Table S4. Percent forest cover within a 1-km radius circular buffer surrounding the study farms.

Farm pair ID	Farm type	Percent forest cover (%)
1	Organic	44.1
	Conventional	47.7
2	Organic	58.5
	Conventional	57.1
3	Organic	30.9
	Conventional	27.3
4	Organic	39.0
	Conventional	0.4
5	Organic	19.1
	Conventional	19.6
6	Organic	13.2
	Conventional	36.5
7	Organic	5.1
	Conventional	8.6

Table S5. Statistical results from GLMM models for examining the effects of year, farm type, crop stage, and percent forest cover (fixed effects) on predator abundance and rice herbivore abundance, with farm ID nested within farm pair ID as a random effect. The number of observations in each year was used as weights in the models. The results of Tukey's post-hoc tests are also presented, with different superscript letters indicating significant differences in the estimated marginal means (EMMs) ($\alpha = 0.05$).

Statistical results from GLMM models

Model	Factor	*d.f.*	χ^2	*P*
Predator abundance	Year	2	64.2	< 0.001
(both spiders and ladybeetles)	Farm type	1	0.006	0.94
	Crop stage	2	40.0	< 0.001
	Percent forest cover	1	1.8	0.18
Rice herbivore abundance	Year	2	30.2	< 0.001
	Farm type	1	0.63	0.43
	Crop stage	2	1.0	0.60
	Percent forest cover	1	2.8	0.10

Tukey's post-hoc tests comparing farm types

Model	Farm type	EMMs (± SE)	Lower 2.5%	Upper 2.5%
Predator abundance	Organic	7.6^{a} (± 1.2)	5.7	10.3
	Conventional	7.7^{a} (± 1.1)	5.8	10.3
Rice herbivore abundance	Organic	41.2^{a} (± 8.1)	28.0	60.6
	Conventional	50.0^{a} (± 9.8)	34.0	73.4

Tukey's post-hoc tests comparing crop stages

Model	Crop stage	EMMs (± SE)	Lower 2.5%	Upper 2.5%
Predator abundance	Tillering	13.8^{a} (± 2.2)	10.2	18.8
	Flowering	4.4^{b} (± 0.7)	3.2	6.1
	Ripening	7.4^{c} (± 1.4)	5.2	10.6
Rice herbivore abundance	Tillering	39.8^{a} (± 8.0)	26.8	59.0
	Flowering	48.0^{a} (± 8.9)	33.4	69.0
	Ripening	48.9^{a} (± 10.5)	32.1	74.6

Table S6. Number of individuals (mean ± SE) from three prey guilds collected using the sweep-net method during the flowering and ripening stages in organic and conventional farms over three study years. Values represent averages across replicate farms.

(a) Flowering stage

Prey guild	Year 2017		Year 2018		Year 2019	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
Rice herbivore	32.7 ± 17.7	54.3 ± 17.2	32.6 ± 7.5	39.1 ± 7.4	100.7 ± 46.4	143.3 ± 53.6
Tourist herbivore	2.5 ± 0.5	3	7.7 ± 6.2	3	1	1
Detritivore	53.7 ± 20	101.3 ± 47.7	6.3 ± 2.7	5.8 ± 3.1	14.9 ± 3.1	12.4 ± 2.9

(b) Ripening stage

Prey guild	Year 2017		Year 2018		Year 2019	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
Rice herbivore	29.0	30.7 ± 20.1	33.3 ± 10.0	29.3 ± 8.8	94.6 ± 33.8	289.0 ± 172.7
Tourist herbivore	NA	NA	3	NA	2.5 ± 1.5	1.7 ± 0.7
Detritivore	6.0 ± 2.0	27.0 ± 22.5	3.5 ± 1.0	2.4 ± 0.9	13.4 ± 4.8	17.8 ± 9.4

Table S7. The trophic discrimination factors (TDFs) (mean ± SD) for the three prey sources in the stable isotope mixing models.

Prey source	$\Delta^{13}C$	$\Delta^{15}N$
Rice herbivore	1.1 ± 0.5	2.4 ± 0.6
Tourist herbivore	0.7 ± 0.6	2.1 ± 0.7
Detritivore	0.9 ± 0.3	1.5 ± 0.9

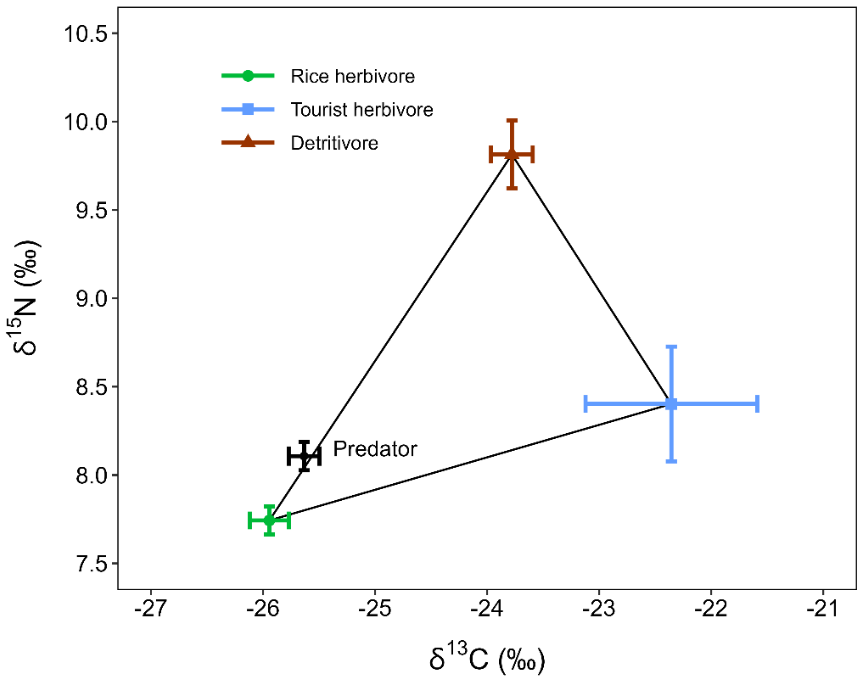
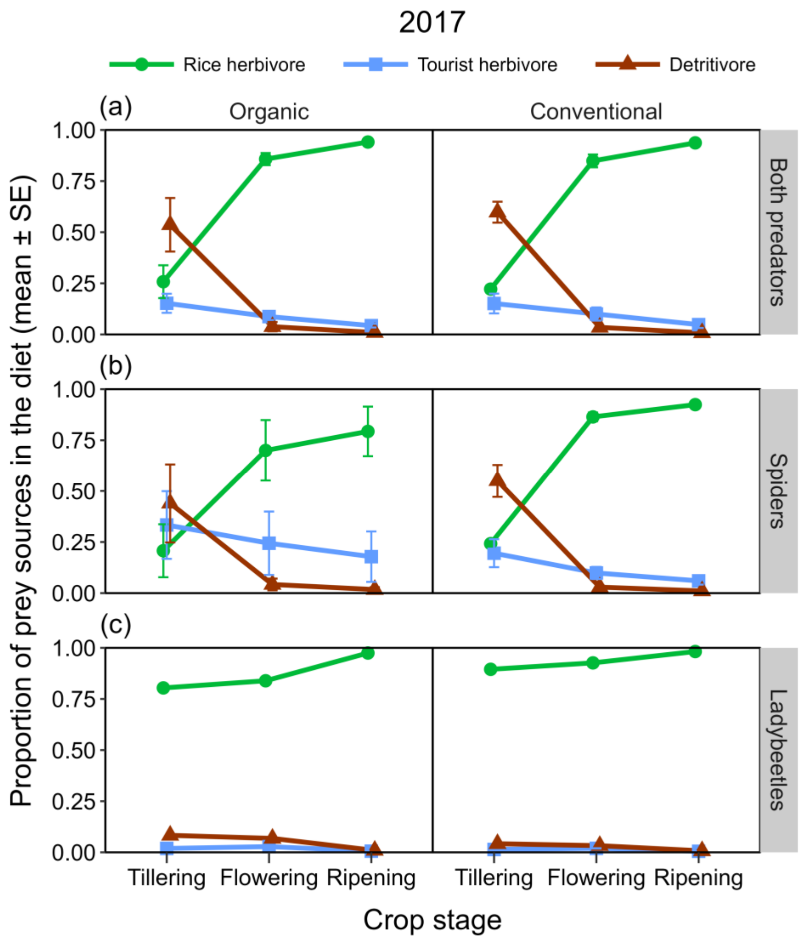
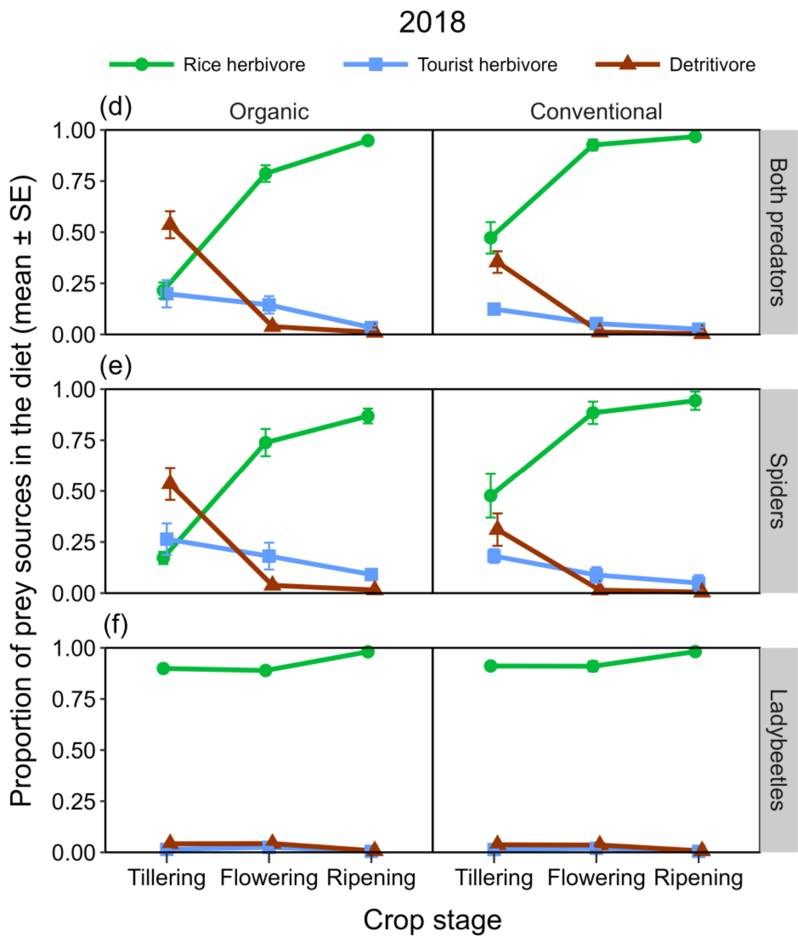


Figure S1. Stable isotope biplot showing the predator and three prey sources in this study. Points represent means and standard errors. The means for the three prey sources are adjusted for the trophic discrimination factors used in the sable isotope mixing models (Table S7).


2017
Rice herbivore
Tourist herbivore
Detritivore
(a)
Organic
Conventional
Both predators
(b)
Spiders
(c)
Ladybeetles
1.00
0.75
0.50
0.25
0.00
Proportion of prey sources in the diet (mean ± SE)
Tillering Flowering Ripening
Tillering Flowering Ripening
Crop stage


2018
Rice herbivore
Tourist herbivore
Detritivore
(d)
Organic
Conventional
Both predators
(e)
Spiders
(f)
Ladybeetles
1.00
0.75
0.50
0.25
0.00
Proportion of prey sources in the diet (mean ± SE)
Tillering
Flowering
Ripening
Crop stage

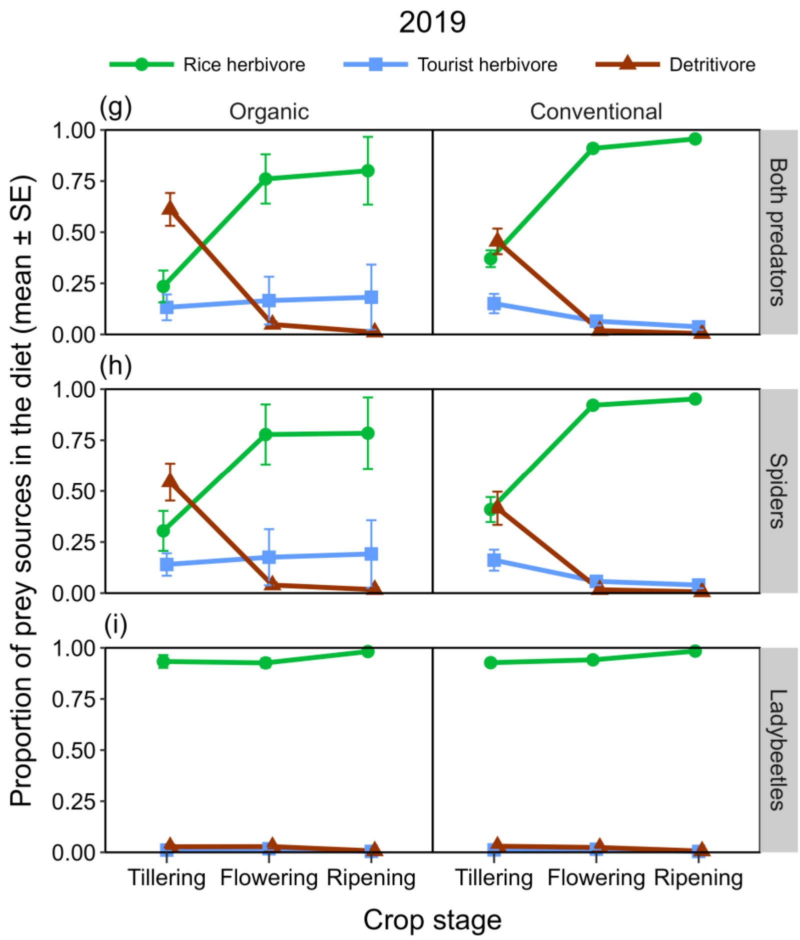


Figure S2. The proportions (mean ± SE) of prey sources (rice herbivores, tourist herbivores, detritivores) consumed in the diet of predators in organic and conventional rice farms over crop stages in each study year: (a), (d), and (g) indicate both predators (spiders and ladybeetles) as a whole feeding guild; (b), (e), and (h) indicate spiders; (c), (f), and (i) indicate ladybeetles. The proportions were computed from the Bayesian posterior medians of diet estimates in replicate farms.

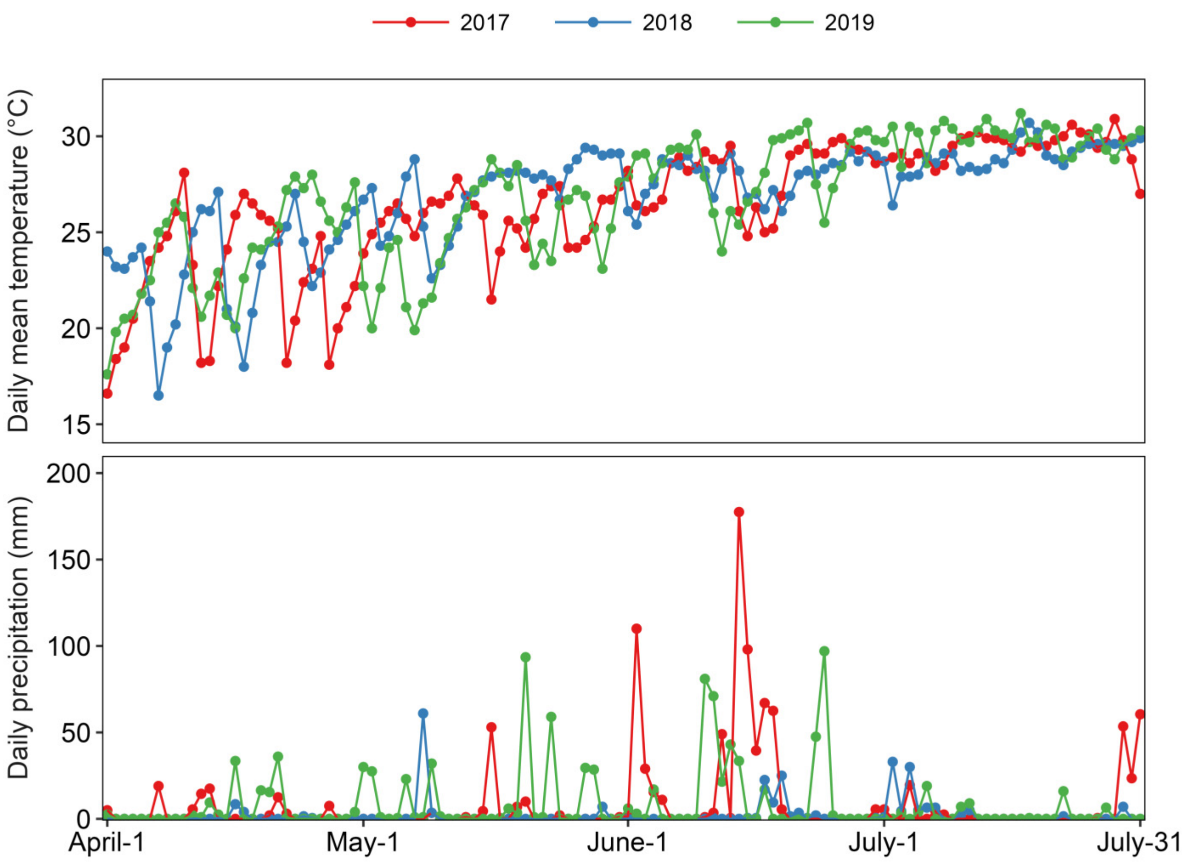


Figure S3. Daily mean temperature and precipitation of the study sites during the rice growth season (April to July) of the three years of study. Observation data from the closest local weather station (Yuanli station) to the study farms were retrieved from the Central Weather Bureau Observation Data Inquire System (https://e-service.cwb.gov.tw/HistoryDataQuery/index.jsp).

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Appendix B. Posterior means, SDs, medians, and 95% credible intervals for the proportion of prey sources in predators' diet based on Bayesian stable isotope mixing models.

Year	Predator	Farm_ID	Crop stage	Prey source	Mean	SD	Median	Lower 95% credible interval limit	Upper 95% credible interval limit
2017	Both	LC1	Tillering	Rice herbivore	0.263	0.068	0.258	0.149	0.418
2017	Both	LC1	Tillering	Tourist herbivore	0.172	0.104	0.145	0.038	0.406
2017	Both	LC1	Tillering	Detritivore	0.564	0.133	0.581	0.299	0.781
2017	Both	LC1	Flowering	Rice herbivore	0.871	0.057	0.879	0.736	0.956
2017	Both	LC1	Flowering	Tourist herbivore	0.097	0.055	0.084	0.026	0.229
2017	Both	LC1	Flowering	Detritivore	0.032	0.02	0.028	0.007	0.085
2017	Both	LC1	Ripening	Rice herbivore	0.945	0.028	0.95	0.879	0.984
2017	Both	LC1	Ripening	Tourist herbivore	0.045	0.025	0.039	0.012	0.109
2017	Both	LC1	Ripening	Detritivore	0.009	0.009	0.006	0.001	0.036
2017	Both	LO1	Tillering	Rice herbivore	0.408	0.166	0.397	0.123	0.758
2017	Both	LO1	Tillering	Tourist herbivore	0.196	0.136	0.174	0.012	0.494
2017	Both	LO1	Tillering	Detritivore	0.396	0.208	0.372	0.067	0.829
2017	Both	LO1	Flowering	Rice herbivore	0.9	0.065	0.913	0.745	0.985
2017	Both	LO1	Flowering	Tourist herbivore	0.081	0.062	0.065	0.006	0.227
2017	Both	LO1	Flowering	Detritivore	0.02	0.022	0.012	0.001	0.088
2017	Both	LO1	Ripening	Rice herbivore	0.956	0.033	0.964	0.87	0.996
2017	Both	LO1	Ripening	Tourist herbivore	0.038	0.032	0.03	0.003	0.122
2017	Both	LO1	Ripening	Detritivore	0.006	0.009	0.003	0	0.029
2017	Both	MC1	Tillering	Rice herbivore	0.221	0.128	0.199	0.036	0.513
2017	Both	MC1	Tillering	Tourist herbivore	0.253	0.155	0.238	0.018	0.598
2017	Both	MC1	Tillering	Detritivore	0.526	0.2	0.519	0.154	0.915
2017	Both	MC1	Flowering	Rice herbivore	0.771	0.127	0.786	0.478	0.962
2017	Both	MC1	Flowering	Tourist herbivore	0.18	0.117	0.162	0.017	0.467
2017	Both	MC1	Flowering	Detritivore	0.049	0.055	0.03	0.003	0.214
2017	Both	MC1	Ripening	Rice herbivore	0.883	0.086	0.905	0.671	0.988
2017	Both	MC1	Ripening	Tourist herbivore	0.1	0.08	0.08	0.008	0.304
2017	Both	MC1	Ripening	Detritivore	0.017	0.029	0.007	0	0.104
2017	Both	MO1	Tillering	Rice herbivore	0.281	0.173	0.258	0.035	0.652

2017	Both	MO1	Tillering	Tourist herbivore	0.274	0.209	0.22	0.016	0.766
2017	Both	MO1	Tillering	Detritivore	0.445	0.194	0.442	0.094	0.824
2017	Both	MO1	Flowering	Rice herbivore	0.767	0.206	0.848	0.302	0.984
2017	Both	MO1	Flowering	Tourist herbivore	0.203	0.197	0.12	0.006	0.656
2017	Both	MO1	Flowering	Detritivore	0.03	0.033	0.019	0.002	0.119
2017	Both	MO1	Ripening	Rice herbivore	0.88	0.126	0.93	0.545	0.994
2017	Both	MO1	Ripening	Tourist herbivore	0.11	0.122	0.06	0.003	0.442
2017	Both	MO1	Ripening	Detritivore	0.01	0.015	0.005	0	0.051
2017	Both	SC1	Tillering	Rice herbivore	0.219	0.115	0.208	0.043	0.47
2017	Both	SC1	Tillering	Tourist herbivore	0.095	0.087	0.071	0.007	0.324
2017	Both	SC1	Tillering	Detritivore	0.685	0.146	0.694	0.37	0.933
2017	Both	SC1	Flowering	Rice herbivore	0.862	0.089	0.881	0.636	0.976
2017	Both	SC1	Flowering	Tourist herbivore	0.075	0.068	0.054	0.006	0.245
2017	Both	SC1	Flowering	Detritivore	0.063	0.056	0.046	0.008	0.216
2017	Both	SC1	Ripening	Rice herbivore	0.943	0.049	0.956	0.809	0.994
2017	Both	SC1	Ripening	Tourist herbivore	0.037	0.038	0.025	0.002	0.142
2017	Both	SC1	Ripening	Detritivore	0.02	0.029	0.01	0.001	0.102
2017	Both	SO1	Tillering	Rice herbivore	0.133	0.083	0.119	0.018	0.331
2017	Both	SO1	Tillering	Tourist herbivore	0.086	0.078	0.063	0.006	0.284
2017	Both	SO1	Tillering	Detritivore	0.781	0.12	0.795	0.522	0.962
2017	Both	SO1	Flowering	Rice herbivore	0.784	0.134	0.812	0.46	0.959
2017	Both	SO1	Flowering	Tourist herbivore	0.103	0.087	0.077	0.008	0.328
2017	Both	SO1	Flowering	Detritivore	0.114	0.1	0.083	0.014	0.404
2017	Both	SO1	Ripening	Rice herbivore	0.911	0.067	0.929	0.747	0.989
2017	Both	SO1	Ripening	Tourist herbivore	0.053	0.048	0.039	0.004	0.179
2017	Both	SO1	Ripening	Detritivore	0.036	0.043	0.02	0.002	0.159
2017	Spider	LC1	Tillering	Rice herbivore	0.248	0.05	0.245	0.163	0.356
2017	Spider	LC1	Tillering	Tourist herbivore	0.283	0.074	0.288	0.116	0.417
2017	Spider	LC1	Tillering	Detritivore	0.469	0.091	0.46	0.316	0.685
2017	Spider	LC1	Flowering	Rice herbivore	0.829	0.05	0.832	0.721	0.916
2017	Spider	LC1	Flowering	Tourist herbivore	0.145	0.047	0.142	0.066	0.247
2017	Spider	LC1	Flowering	Detritivore	0.026	0.018	0.022	0.005	0.071

2017	Spider	LC1	Ripening	Rice herbivore	0.897	0.039	0.902	0.806	0.961
2017	Spider	LC1	Ripening	Tourist herbivore	0.091	0.037	0.087	0.032	0.177
2017	Spider	LC1	Ripening	Detritivore	0.012	0.013	0.008	0.001	0.048
2017	Spider	LO1	Tillering	Rice herbivore	0.464	0.127	0.466	0.215	0.71
2017	Spider	LO1	Tillering	Tourist herbivore	0.28	0.107	0.283	0.055	0.486
2017	Spider	LO1	Tillering	Detritivore	0.256	0.157	0.223	0.046	0.662
2017	Spider	LO1	Flowering	Rice herbivore	0.905	0.04	0.909	0.816	0.969
2017	Spider	LO1	Flowering	Tourist herbivore	0.086	0.039	0.082	0.022	0.172
2017	Spider	LO1	Flowering	Detritivore	0.009	0.01	0.006	0.001	0.04
2017	Spider	LO1	Ripening	Rice herbivore	0.943	0.03	0.948	0.872	0.986
2017	Spider	LO1	Ripening	Tourist herbivore	0.052	0.029	0.048	0.01	0.122
2017	Spider	LO1	Ripening	Detritivore	0.004	0.007	0.002	0	0.023
2017	Spider	MC1	Tillering	Rice herbivore	0.271	0.106	0.265	0.09	0.494
2017	Spider	MC1	Tillering	Tourist herbivore	0.24	0.111	0.236	0.043	0.474
2017	Spider	MC1	Tillering	Detritivore	0.488	0.171	0.483	0.169	0.836
2017	Spider	MC1	Flowering	Rice herbivore	0.85	0.061	0.856	0.712	0.949
2017	Spider	MC1	Flowering	Tourist herbivore	0.119	0.055	0.112	0.032	0.244
2017	Spider	MC1	Flowering	Detritivore	0.031	0.031	0.022	0.003	0.115
2017	Spider	MC1	Ripening	Rice herbivore	0.91	0.047	0.918	0.802	0.977
2017	Spider	MC1	Ripening	Tourist herbivore	0.075	0.041	0.068	0.016	0.173
2017	Spider	MC1	Ripening	Detritivore	0.015	0.022	0.008	0	0.078
2017	Spider	MO1	Tillering	Rice herbivore	0.074	0.042	0.065	0.019	0.175
2017	Spider	MO1	Tillering	Tourist herbivore	0.618	0.179	0.642	0.23	0.892
2017	Spider	MO1	Tillering	Detritivore	0.308	0.189	0.274	0.039	0.732
2017	Spider	MO1	Flowering	Rice herbivore	0.412	0.107	0.412	0.204	0.622
2017	Spider	MO1	Flowering	Tourist herbivore	0.556	0.104	0.554	0.358	0.761
2017	Spider	MO1	Flowering	Detritivore	0.032	0.034	0.022	0.002	0.117
2017	Spider	MO1	Ripening	Rice herbivore	0.551	0.116	0.554	0.316	0.767
2017	Spider	MO1	Ripening	Tourist herbivore	0.43	0.114	0.425	0.22	0.663
2017	Spider	MO1	Ripening	Detritivore	0.019	0.024	0.01	0.001	0.089
2017	Spider	SC1	Tillering	Rice herbivore	0.221	0.109	0.216	0.042	0.446
2017	Spider	SC1	Tillering	Tourist herbivore	0.073	0.051	0.062	0.01	0.202

2017	Spider	SC1	Tillering	Detritivore	0.705	0.125	0.707	0.457	0.924
2017	Spider	SC1	Flowering	Rice herbivore	0.885	0.077	0.905	0.687	0.975
2017	Spider	SC1	Flowering	Tourist herbivore	0.054	0.044	0.042	0.006	0.165
2017	Spider	SC1	Flowering	Detritivore	0.062	0.055	0.044	0.007	0.217
2017	Spider	SC1	Ripening	Rice herbivore	0.932	0.065	0.953	0.743	0.992
2017	Spider	SC1	Ripening	Tourist herbivore	0.034	0.033	0.025	0.003	0.123
2017	Spider	SC1	Ripening	Detritivore	0.033	0.05	0.016	0.001	0.181
2017	Spider	SO1	Tillering	Rice herbivore	0.105	0.066	0.091	0.018	0.27
2017	Spider	SO1	Tillering	Tourist herbivore	0.086	0.056	0.075	0.01	0.224
2017	Spider	SO1	Tillering	Detritivore	0.809	0.096	0.822	0.6	0.958
2017	Spider	SO1	Flowering	Rice herbivore	0.759	0.128	0.779	0.463	0.946
2017	Spider	SO1	Flowering	Tourist herbivore	0.112	0.074	0.096	0.015	0.286
2017	Spider	SO1	Flowering	Detritivore	0.13	0.103	0.099	0.015	0.408
2017	Spider	SO1	Ripening	Rice herbivore	0.86	0.09	0.878	0.645	0.977
2017	Spider	SO1	Ripening	Tourist herbivore	0.075	0.055	0.062	0.009	0.214
2017	Spider	SO1	Ripening	Detritivore	0.066	0.07	0.04	0.003	0.259
2017	Ladybeetle	LC1	Flowering	Rice herbivore	0.902	0.131	0.934	0.456	0.991
2017	Ladybeetle	LC1	Flowering	Tourist herbivore	0.054	0.124	0.02	0	0.498
2017	Ladybeetle	LC1	Flowering	Detritivore	0.045	0.041	0.033	0.001	0.151
2017	Ladybeetle	LC1	Ripening	Rice herbivore	0.955	0.137	0.984	0.498	0.998
2017	Ladybeetle	LC1	Ripening	Tourist herbivore	0.033	0.135	0.005	0	0.472
2017	Ladybeetle	LC1	Ripening	Detritivore	0.012	0.014	0.007	0	0.049
2017	Ladybeetle	LO1	Ripening	Rice herbivore	0.944	0.143	0.984	0.474	0.999
2017	Ladybeetle	LO1	Ripening	Tourist herbivore	0.038	0.138	0.004	0	0.518
2017	Ladybeetle	LO1	Ripening	Detritivore	0.018	0.032	0.006	0	0.11
2017	Ladybeetle	MC1	Tillering	Rice herbivore	0.803	0.228	0.895	0.139	0.998
2017	Ladybeetle	MC1	Tillering	Tourist herbivore	0.08	0.165	0.014	0	0.657
2017	Ladybeetle	MC1	Tillering	Detritivore	0.118	0.165	0.042	0	0.605
2017	Ladybeetle	MO1	Tillering	Rice herbivore	0.74	0.239	0.804	0.153	0.998
2017	Ladybeetle	MO1	Tillering	Tourist herbivore	0.086	0.162	0.019	0	0.622
2017	Ladybeetle	MO1	Tillering	Detritivore	0.173	0.198	0.083	0	0.656
2017	Ladybeetle	MO1	Flowering	Rice herbivore	0.792	0.188	0.839	0.311	0.996

2017	Ladybeetle	MO1	Flowering	Tourist herbivore	0.085	0.141	0.028	0	0.53
2017	Ladybeetle	MO1	Flowering	Detritivore	0.123	0.138	0.068	0.001	0.484
2017	Ladybeetle	MO1	Ripening	Rice herbivore	0.914	0.141	0.959	0.515	0.999
2017	Ladybeetle	MO1	Ripening	Tourist herbivore	0.046	0.128	0.008	0	0.442
2017	Ladybeetle	MO1	Ripening	Detritivore	0.04	0.059	0.015	0	0.222
2017	Ladybeetle	SC1	Flowering	Rice herbivore	0.863	0.16	0.919	0.407	0.997
2017	Ladybeetle	SC1	Flowering	Tourist herbivore	0.069	0.133	0.019	0	0.5
2017	Ladybeetle	SC1	Flowering	Detritivore	0.068	0.091	0.032	0.001	0.324
2017	Ladybeetle	SC1	Ripening	Rice herbivore	0.94	0.138	0.98	0.565	0.999
2017	Ladybeetle	SC1	Ripening	Tourist herbivore	0.039	0.131	0.005	0	0.394
2017	Ladybeetle	SC1	Ripening	Detritivore	0.022	0.039	0.007	0	0.136
2017	Ladybeetle	SO1	Ripening	Rice herbivore	0.938	0.143	0.981	0.521	0.999
2017	Ladybeetle	SO1	Ripening	Tourist herbivore	0.039	0.134	0.005	0	0.477
2017	Ladybeetle	SO1	Ripening	Detritivore	0.023	0.044	0.007	0	0.165
2018	Both	LC1	Tillering	Rice herbivore	0.389	0.194	0.383	0.053	0.773
2018	Both	LC1	Tillering	Tourist herbivore	0.178	0.168	0.117	0.008	0.594
2018	Both	LC1	Tillering	Detritivore	0.432	0.225	0.398	0.077	0.911
2018	Both	LC1	Flowering	Rice herbivore	0.883	0.114	0.923	0.559	0.991
2018	Both	LC1	Flowering	Tourist herbivore	0.087	0.1	0.049	0.004	0.38
2018	Both	LC1	Flowering	Detritivore	0.03	0.053	0.013	0.001	0.183
2018	Both	LC1	Ripening	Rice herbivore	0.952	0.049	0.969	0.826	0.997
2018	Both	LC1	Ripening	Tourist herbivore	0.04	0.046	0.024	0.002	0.161
2018	Both	LC1	Ripening	Detritivore	0.008	0.013	0.003	0	0.045
2018	Both	LC2	Tillering	Rice herbivore	0.309	0.174	0.288	0.045	0.694
2018	Both	LC2	Tillering	Tourist herbivore	0.174	0.144	0.139	0.009	0.544
2018	Both	LC2	Tillering	Detritivore	0.517	0.213	0.524	0.107	0.902
2018	Both	LC2	Ripening	Rice herbivore	0.932	0.073	0.956	0.732	0.995
2018	Both	LC2	Ripening	Tourist herbivore	0.056	0.067	0.033	0.002	0.244
2018	Both	LC2	Ripening	Detritivore	0.012	0.021	0.005	0	0.071
2018	Both	LC3	Tillering	Rice herbivore	0.669	0.108	0.671	0.445	0.876
2018	Both	LC3	Tillering	Tourist herbivore	0.09	0.075	0.069	0.007	0.281
2018	Both	LC3	Tillering	Detritivore	0.241	0.11	0.234	0.057	0.475

2018	Both	LC3	Flowering	Rice herbivore	0.969	0.028	0.977	0.901	0.995
2018	Both	LC3	Flowering	Tourist herbivore	0.025	0.027	0.016	0.002	0.092
2018	Both	LC3	Flowering	Detritivore	0.006	0.006	0.005	0.001	0.022
2018	Both	LC3	Ripening	Rice herbivore	0.987	0.012	0.991	0.955	0.999
2018	Both	LC3	Ripening	Tourist herbivore	0.011	0.012	0.007	0.001	0.042
2018	Both	LC3	Ripening	Detritivore	0.002	0.002	0.001	0	0.008
2018	Both	LO1	Tillering	Rice herbivore	0.315	0.136	0.31	0.058	0.59
2018	Both	LO1	Tillering	Tourist herbivore	0.283	0.152	0.277	0.023	0.593
2018	Both	LO1	Tillering	Detritivore	0.402	0.172	0.387	0.106	0.79
2018	Both	LO1	Flowering	Rice herbivore	0.817	0.139	0.851	0.431	0.976
2018	Both	LO1	Flowering	Tourist herbivore	0.159	0.132	0.126	0.012	0.527
2018	Both	LO1	Flowering	Detritivore	0.024	0.029	0.015	0.002	0.104
2018	Both	LO1	Ripening	Rice herbivore	0.905	0.103	0.936	0.584	0.991
2018	Both	LO1	Ripening	Tourist herbivore	0.088	0.1	0.057	0.005	0.399
2018	Both	LO1	Ripening	Detritivore	0.007	0.011	0.004	0	0.037
2018	Both	LO2	Tillering	Rice herbivore	0.295	0.143	0.288	0.058	0.606
2018	Both	LO2	Tillering	Tourist herbivore	0.139	0.13	0.097	0.007	0.489
2018	Both	LO2	Tillering	Detritivore	0.565	0.187	0.567	0.184	0.896
2018	Both	LO2	Flowering	Rice herbivore	0.877	0.096	0.906	0.611	0.982
2018	Both	LO2	Flowering	Tourist herbivore	0.082	0.083	0.055	0.005	0.31
2018	Both	LO2	Flowering	Detritivore	0.04	0.045	0.026	0.004	0.169
2018	Both	LO2	Ripening	Rice herbivore	0.949	0.047	0.964	0.817	0.995
2018	Both	LO2	Ripening	Tourist herbivore	0.039	0.042	0.025	0.002	0.159
2018	Both	LO2	Ripening	Detritivore	0.012	0.017	0.006	0	0.058
2018	Both	LO3	Tillering	Rice herbivore	0.364	0.174	0.365	0.06	0.706
2018	Both	LO3	Tillering	Tourist herbivore	0.101	0.145	0.046	0.005	0.568
2018	Both	LO3	Tillering	Detritivore	0.536	0.198	0.527	0.143	0.906
2018	Both	LO3	Ripening	Rice herbivore	0.966	0.043	0.981	0.838	0.998
2018	Both	LO3	Ripening	Tourist herbivore	0.025	0.04	0.011	0.001	0.144
2018	Both	LO3	Ripening	Detritivore	0.01	0.015	0.005	0	0.049
2018	Both	MC1	Tillering	Rice herbivore	0.691	0.168	0.722	0.276	0.926
2018	Both	MC1	Tillering	Tourist herbivore	0.075	0.073	0.056	0.006	0.255

2018	Both	MC1	Tillering	Detritivore	0.234	0.171	0.188	0.027	0.659
2018	Both	MC1	Flowering	Rice herbivore	0.971	0.034	0.98	0.897	0.997
2018	Both	MC1	Flowering	Tourist herbivore	0.022	0.031	0.013	0.001	0.087
2018	Both	MC1	Flowering	Detritivore	0.007	0.011	0.004	0	0.033
2018	Both	MC1	Ripening	Rice herbivore	0.988	0.02	0.992	0.956	0.999
2018	Both	MC1	Ripening	Tourist herbivore	0.01	0.018	0.006	0.001	0.04
2018	Both	MC1	Ripening	Detritivore	0.002	0.005	0.001	0	0.011
2018	Both	MC2	Tillering	Rice herbivore	0.599	0.217	0.646	0.108	0.908
2018	Both	MC2	Tillering	Tourist herbivore	0.114	0.107	0.083	0.007	0.408
2018	Both	MC2	Tillering	Detritivore	0.287	0.219	0.221	0.033	0.829
2018	Both	MC2	Flowering	Rice herbivore	0.944	0.072	0.966	0.752	0.996
2018	Both	MC2	Flowering	Tourist herbivore	0.042	0.062	0.024	0.002	0.199
2018	Both	MC2	Flowering	Detritivore	0.014	0.029	0.005	0	0.087
2018	Both	MC2	Ripening	Rice herbivore	0.976	0.039	0.987	0.874	0.999
2018	Both	MC2	Ripening	Tourist herbivore	0.02	0.033	0.01	0.001	0.108
2018	Both	MC2	Ripening	Detritivore	0.004	0.014	0.001	0	0.026
2018	Both	MC3	Tillering	Rice herbivore	0.233	0.139	0.214	0.031	0.547
2018	Both	MC3	Tillering	Tourist herbivore	0.248	0.159	0.235	0.014	0.591
2018	Both	MC3	Tillering	Detritivore	0.518	0.206	0.509	0.138	0.915
2018	Both	MC3	Flowering	Rice herbivore	0.773	0.15	0.807	0.417	0.971
2018	Both	MC3	Flowering	Tourist herbivore	0.178	0.134	0.148	0.011	0.506
2018	Both	MC3	Flowering	Detritivore	0.049	0.066	0.027	0.003	0.239
2018	Both	MC3	Ripening	Rice herbivore	0.886	0.099	0.915	0.625	0.99
2018	Both	MC3	Ripening	Tourist herbivore	0.098	0.09	0.07	0.006	0.334
2018	Both	MC3	Ripening	Detritivore	0.016	0.03	0.007	0	0.097
2018	Both	MO1	Tillering	Rice herbivore	0.225	0.207	0.165	0.007	0.72
2018	Both	MO1	Tillering	Tourist herbivore	0.172	0.177	0.109	0.005	0.659
2018	Both	MO1	Tillering	Detritivore	0.602	0.278	0.618	0.097	0.984
2018	Both	MO1	Flowering	Rice herbivore	0.719	0.226	0.788	0.246	0.985
2018	Both	MO1	Flowering	Tourist herbivore	0.148	0.145	0.101	0.006	0.554
2018	Both	MO1	Flowering	Detritivore	0.133	0.183	0.036	0.002	0.619
2018	Both	MO1	Ripening	Rice herbivore	0.872	0.119	0.913	0.573	0.994

2018	Both	MO1	Ripening	Tourist herbivore	0.087	0.094	0.055	0.003	0.352
2018	Both	MO1	Ripening	Detritivore	0.041	0.066	0.011	0	0.237
2018	Both	MO2	Tillering	Rice herbivore	0.161	0.115	0.135	0.023	0.431
2018	Both	MO2	Tillering	Tourist herbivore	0.452	0.241	0.507	0.007	0.831
2018	Both	MO2	Tillering	Detritivore	0.387	0.271	0.306	0.051	0.955
2018	Both	MO2	Flowering	Rice herbivore	0.629	0.188	0.656	0.215	0.921
2018	Both	MO2	Flowering	Tourist herbivore	0.322	0.201	0.296	0.019	0.754
2018	Both	MO2	Flowering	Detritivore	0.049	0.08	0.019	0.002	0.303
2018	Both	MO3	Tillering	Rice herbivore	0.157	0.112	0.132	0.02	0.429
2018	Both	MO3	Tillering	Tourist herbivore	0.324	0.199	0.324	0.012	0.726
2018	Both	MO3	Tillering	Detritivore	0.519	0.236	0.5	0.102	0.946
2018	Both	MO3	Flowering	Rice herbivore	0.661	0.181	0.68	0.247	0.939
2018	Both	MO3	Flowering	Tourist herbivore	0.272	0.175	0.247	0.022	0.691
2018	Both	MO3	Flowering	Detritivore	0.066	0.085	0.033	0.003	0.336
2018	Both	SC1	Tillering	Rice herbivore	0.385	0.162	0.384	0.091	0.709
2018	Both	SC1	Tillering	Tourist herbivore	0.191	0.129	0.17	0.013	0.486
2018	Both	SC1	Tillering	Detritivore	0.424	0.198	0.404	0.094	0.831
2018	Both	SC1	Flowering	Rice herbivore	0.884	0.088	0.907	0.651	0.986
2018	Both	SC1	Flowering	Tourist herbivore	0.091	0.078	0.07	0.006	0.298
2018	Both	SC1	Flowering	Detritivore	0.025	0.037	0.014	0.002	0.116
2018	Both	SC1	Ripening	Rice herbivore	0.948	0.046	0.963	0.819	0.996
2018	Both	SC1	Ripening	Tourist herbivore	0.045	0.043	0.031	0.003	0.168
2018	Both	SC1	Ripening	Detritivore	0.007	0.014	0.003	0	0.039
2018	Both	SO1	Tillering	Rice herbivore	0.121	0.069	0.108	0.027	0.287
2018	Both	SO1	Tillering	Tourist herbivore	0.041	0.035	0.032	0.004	0.132
2018	Both	SO1	Tillering	Detritivore	0.838	0.082	0.85	0.651	0.96
2018	Both	SO1	Flowering	Rice herbivore	0.822	0.097	0.84	0.586	0.957
2018	Both	SO1	Flowering	Tourist herbivore	0.058	0.052	0.042	0.005	0.189
2018	Both	SO1	Flowering	Detritivore	0.12	0.08	0.101	0.021	0.325
2018	Both	SO1	Ripening	Rice herbivore	0.932	0.054	0.947	0.793	0.991
2018	Both	SO1	Ripening	Tourist herbivore	0.03	0.03	0.02	0.002	0.111
2018	Both	SO1	Ripening	Detritivore	0.038	0.042	0.024	0.002	0.157

2018	Spider	LC1	Tillering	Rice herbivore	0.12	0.104	0.088	0.007	0.373
2018	Spider	LC1	Tillering	Tourist herbivore	0.262	0.152	0.247	0.027	0.607
2018	Spider	LC1	Tillering	Detritivore	0.618	0.194	0.617	0.227	0.953
2018	Spider	LC1	Flowering	Rice herbivore	0.606	0.222	0.642	0.163	0.927
2018	Spider	LC1	Flowering	Tourist herbivore	0.282	0.173	0.249	0.04	0.684
2018	Spider	LC1	Flowering	Detritivore	0.112	0.139	0.053	0.006	0.521
2018	Spider	LC2	Tillering	Rice herbivore	0.297	0.162	0.285	0.034	0.65
2018	Spider	LC2	Tillering	Tourist herbivore	0.205	0.134	0.182	0.025	0.541
2018	Spider	LC2	Tillering	Detritivore	0.498	0.207	0.499	0.111	0.884
2018	Spider	LC3	Tillering	Rice herbivore	0.717	0.101	0.72	0.516	0.907
2018	Spider	LC3	Tillering	Tourist herbivore	0.094	0.062	0.081	0.014	0.243
2018	Spider	LC3	Tillering	Detritivore	0.189	0.101	0.178	0.031	0.413
2018	Spider	LC3	Flowering	Rice herbivore	0.975	0.017	0.978	0.935	0.996
2018	Spider	LC3	Flowering	Tourist herbivore	0.02	0.016	0.016	0.002	0.06
2018	Spider	LC3	Flowering	Detritivore	0.004	0.005	0.003	0	0.016
2018	Spider	LO1	Tillering	Rice herbivore	0.191	0.107	0.173	0.039	0.443
2018	Spider	LO1	Tillering	Tourist herbivore	0.38	0.14	0.372	0.119	0.677
2018	Spider	LO1	Tillering	Detritivore	0.429	0.177	0.424	0.103	0.787
2018	Spider	LO1	Flowering	Rice herbivore	0.708	0.14	0.729	0.38	0.915
2018	Spider	LO1	Flowering	Tourist herbivore	0.256	0.127	0.236	0.07	0.551
2018	Spider	LO1	Flowering	Detritivore	0.036	0.043	0.024	0.002	0.144
2018	Spider	LO1	Ripening	Rice herbivore	0.806	0.116	0.83	0.522	0.956
2018	Spider	LO1	Ripening	Tourist herbivore	0.175	0.106	0.153	0.037	0.432
2018	Spider	LO1	Ripening	Detritivore	0.019	0.033	0.009	0	0.088
2018	Spider	LO2	Tillering	Rice herbivore	0.332	0.115	0.328	0.115	0.568
2018	Spider	LO2	Tillering	Tourist herbivore	0.204	0.096	0.199	0.034	0.411
2018	Spider	LO2	Tillering	Detritivore	0.464	0.16	0.455	0.174	0.8
2018	Spider	LO2	Flowering	Rice herbivore	0.887	0.055	0.896	0.755	0.968
2018	Spider	LO2	Flowering	Tourist herbivore	0.088	0.047	0.08	0.018	0.195
2018	Spider	LO2	Flowering	Detritivore	0.025	0.026	0.017	0.002	0.097
2018	Spider	LO2	Ripening	Rice herbivore	0.934	0.038	0.941	0.842	0.985
2018	Spider	LO2	Ripening	Tourist herbivore	0.054	0.033	0.048	0.009	0.137

2018	Spider	LO2	Ripening	Detritivore	0.012	0.016	0.006	0	0.055
2018	Spider	LO3	Tillering	Rice herbivore	0.215	0.112	0.201	0.04	0.458
2018	Spider	LO3	Tillering	Tourist herbivore	0.171	0.105	0.156	0.018	0.416
2018	Spider	LO3	Tillering	Detritivore	0.614	0.169	0.624	0.273	0.914
2018	Spider	LO3	Ripening	Rice herbivore	0.9	0.07	0.917	0.71	0.982
2018	Spider	LO3	Ripening	Tourist herbivore	0.072	0.051	0.06	0.01	0.2
2018	Spider	LO3	Ripening	Detritivore	0.029	0.043	0.013	0.001	0.159
2018	Spider	MC1	Tillering	Rice herbivore	0.757	0.099	0.764	0.549	0.929
2018	Spider	MC1	Tillering	Tourist herbivore	0.12	0.08	0.104	0.015	0.307
2018	Spider	MC1	Tillering	Detritivore	0.123	0.077	0.107	0.021	0.316
2018	Spider	MC1	Flowering	Rice herbivore	0.972	0.022	0.977	0.915	0.996
2018	Spider	MC1	Flowering	Tourist herbivore	0.025	0.022	0.02	0.003	0.081
2018	Spider	MC1	Flowering	Detritivore	0.003	0.003	0.002	0	0.011
2018	Spider	MC1	Ripening	Rice herbivore	0.984	0.015	0.988	0.946	0.998
2018	Spider	MC1	Ripening	Tourist herbivore	0.015	0.015	0.011	0.001	0.052
2018	Spider	MC1	Ripening	Detritivore	0.001	0.002	0.001	0	0.007
2018	Spider	MC2	Tillering	Rice herbivore	0.773	0.104	0.787	0.54	0.936
2018	Spider	MC2	Tillering	Tourist herbivore	0.111	0.075	0.096	0.014	0.288
2018	Spider	MC2	Tillering	Detritivore	0.116	0.088	0.095	0.018	0.347
2018	Spider	MC2	Flowering	Rice herbivore	0.974	0.021	0.98	0.92	0.996
2018	Spider	MC2	Flowering	Tourist herbivore	0.023	0.021	0.018	0.002	0.075
2018	Spider	MC2	Flowering	Detritivore	0.003	0.004	0.002	0	0.012
2018	Spider	MC3	Tillering	Rice herbivore	0.251	0.119	0.241	0.056	0.515
2018	Spider	MC3	Tillering	Tourist herbivore	0.283	0.123	0.279	0.057	0.541
2018	Spider	MC3	Tillering	Detritivore	0.465	0.181	0.457	0.137	0.839
2018	Spider	MC3	Flowering	Rice herbivore	0.808	0.098	0.824	0.564	0.947
2018	Spider	MC3	Flowering	Tourist herbivore	0.158	0.084	0.144	0.035	0.358
2018	Spider	MC3	Flowering	Detritivore	0.035	0.042	0.022	0.002	0.153
2018	Spider	MC3	Ripening	Rice herbivore	0.881	0.073	0.899	0.695	0.975
2018	Spider	MC3	Ripening	Tourist herbivore	0.102	0.065	0.088	0.018	0.257
2018	Spider	MC3	Ripening	Detritivore	0.017	0.028	0.008	0	0.096
2018	Spider	MO1	Tillering	Rice herbivore	0.167	0.194	0.072	0.004	0.655

2018	Spider	MO1	Tillering	Tourist herbivore	0.181	0.185	0.109	0.006	0.658
2018	Spider	MO1	Tillering	Detritivore	0.652	0.306	0.754	0.086	0.987
2018	Spider	MO1	Flowering	Rice herbivore	0.607	0.26	0.61	0.188	0.974
2018	Spider	MO1	Flowering	Tourist herbivore	0.166	0.126	0.138	0.016	0.501
2018	Spider	MO1	Flowering	Detritivore	0.227	0.246	0.074	0.001	0.709
2018	Spider	MO1	Ripening	Rice herbivore	0.746	0.2	0.787	0.272	0.985
2018	Spider	MO1	Ripening	Tourist herbivore	0.129	0.106	0.103	0.009	0.388
2018	Spider	MO1	Ripening	Detritivore	0.125	0.175	0.033	0	0.612
2018	Spider	MO2	Tillering	Rice herbivore	0.147	0.078	0.135	0.03	0.33
2018	Spider	MO2	Tillering	Tourist herbivore	0.649	0.119	0.649	0.424	0.877
2018	Spider	MO2	Tillering	Detritivore	0.204	0.115	0.19	0.032	0.455
2018	Spider	MO2	Flowering	Rice herbivore	0.558	0.156	0.576	0.203	0.81
2018	Spider	MO2	Flowering	Tourist herbivore	0.427	0.153	0.409	0.182	0.767
2018	Spider	MO2	Flowering	Detritivore	0.016	0.018	0.01	0.001	0.06
2018	Spider	MO3	Tillering	Rice herbivore	0.165	0.107	0.147	0.019	0.419
2018	Spider	MO3	Tillering	Tourist herbivore	0.327	0.153	0.316	0.052	0.663
2018	Spider	MO3	Tillering	Detritivore	0.509	0.189	0.506	0.152	0.877
2018	Spider	SC1	Tillering	Rice herbivore	0.439	0.155	0.453	0.102	0.715
2018	Spider	SC1	Tillering	Tourist herbivore	0.287	0.125	0.281	0.066	0.554
2018	Spider	SC1	Tillering	Detritivore	0.274	0.19	0.222	0.041	0.773
2018	Spider	SC1	Flowering	Rice herbivore	0.883	0.08	0.905	0.67	0.973
2018	Spider	SC1	Flowering	Tourist herbivore	0.103	0.071	0.085	0.02	0.281
2018	Spider	SC1	Flowering	Detritivore	0.014	0.03	0.006	0.001	0.089
2018	Spider	SO1	Tillering	Rice herbivore	0.162	0.077	0.15	0.046	0.337
2018	Spider	SO1	Tillering	Tourist herbivore	0.056	0.039	0.047	0.007	0.152
2018	Spider	SO1	Tillering	Detritivore	0.782	0.091	0.793	0.581	0.931
2018	Spider	SO1	Flowering	Rice herbivore	0.869	0.069	0.882	0.707	0.966
2018	Spider	SO1	Flowering	Tourist herbivore	0.051	0.037	0.042	0.007	0.144
2018	Spider	SO1	Flowering	Detritivore	0.079	0.055	0.065	0.013	0.215
2018	Ladybeetle	LC1	Tillering	Rice herbivore	0.859	0.191	0.931	0.189	0.998
2018	Ladybeetle	LC1	Tillering	Tourist herbivore	0.067	0.159	0.012	0	0.671
2018	Ladybeetle	LC1	Tillering	Detritivore	0.074	0.109	0.03	0	0.389

2018	Ladybeetle	LC1	Ripening	Rice herbivore	0.95	0.138	0.986	0.51	0.999
2018	Ladybeetle	LC1	Ripening	Tourist herbivore	0.036	0.135	0.004	0	0.476
2018	Ladybeetle	LC1	Ripening	Detritivore	0.014	0.024	0.005	0	0.083
2018	Ladybeetle	LC2	Ripening	Rice herbivore	0.936	0.147	0.982	0.457	0.999
2018	Ladybeetle	LC2	Ripening	Tourist herbivore	0.042	0.139	0.005	0	0.501
2018	Ladybeetle	LC2	Ripening	Detritivore	0.023	0.045	0.006	0	0.152
2018	Ladybeetle	LC3	Tillering	Rice herbivore	0.854	0.187	0.924	0.197	0.998
2018	Ladybeetle	LC3	Tillering	Tourist herbivore	0.066	0.152	0.013	0	0.604
2018	Ladybeetle	LC3	Tillering	Detritivore	0.081	0.112	0.032	0	0.405
2018	Ladybeetle	LC3	Flowering	Rice herbivore	0.888	0.148	0.935	0.421	0.997
2018	Ladybeetle	LC3	Flowering	Tourist herbivore	0.06	0.129	0.016	0	0.51
2018	Ladybeetle	LC3	Flowering	Detritivore	0.052	0.069	0.026	0.001	0.253
2018	Ladybeetle	LC3	Ripening	Rice herbivore	0.948	0.14	0.985	0.388	0.999
2018	Ladybeetle	LC3	Ripening	Tourist herbivore	0.037	0.136	0.004	0	0.588
2018	Ladybeetle	LC3	Ripening	Detritivore	0.015	0.026	0.006	0	0.087
2018	Ladybeetle	LO1	Tillering	Rice herbivore	0.77	0.216	0.825	0.21	0.998
2018	Ladybeetle	LO1	Tillering	Tourist herbivore	0.094	0.162	0.021	0	0.589
2018	Ladybeetle	LO1	Tillering	Detritivore	0.135	0.159	0.07	0	0.543
2018	Ladybeetle	LO1	Flowering	Rice herbivore	0.816	0.18	0.869	0.322	0.995
2018	Ladybeetle	LO1	Flowering	Tourist herbivore	0.091	0.149	0.029	0	0.578
2018	Ladybeetle	LO1	Flowering	Detritivore	0.093	0.111	0.053	0.001	0.411
2018	Ladybeetle	LO1	Ripening	Rice herbivore	0.92	0.153	0.968	0.347	0.999
2018	Ladybeetle	LO1	Ripening	Tourist herbivore	0.052	0.145	0.008	0	0.611
2018	Ladybeetle	LO1	Ripening	Detritivore	0.028	0.046	0.012	0	0.154
2018	Ladybeetle	LO2	Tillering	Rice herbivore	0.827	0.228	0.925	0.11	0.998
2018	Ladybeetle	LO2	Tillering	Tourist herbivore	0.07	0.17	0.013	0	0.782
2018	Ladybeetle	LO2	Tillering	Detritivore	0.103	0.163	0.031	0	0.591
2018	Ladybeetle	LO2	Ripening	Rice herbivore	0.94	0.144	0.983	0.497	0.999
2018	Ladybeetle	LO2	Ripening	Tourist herbivore	0.039	0.137	0.004	0	0.461
2018	Ladybeetle	LO2	Ripening	Detritivore	0.021	0.041	0.006	0	0.136
2018	Ladybeetle	LO3	Tillering	Rice herbivore	0.831	0.212	0.915	0.115	0.998
2018	Ladybeetle	LO3	Tillering	Tourist herbivore	0.063	0.159	0.012	0	0.681

2018	Ladybeetle	LO3	Tillering	Detritivore	0.106	0.148	0.038	0	0.524
2018	Ladybeetle	LO3	Ripening	Rice herbivore	0.944	0.144	0.983	0.437	0.999
2018	Ladybeetle	LO3	Ripening	Tourist herbivore	0.036	0.138	0.004	0	0.533
2018	Ladybeetle	LO3	Ripening	Detritivore	0.02	0.034	0.007	0	0.116
2018	Ladybeetle	MC1	Tillering	Rice herbivore	0.829	0.223	0.921	0.127	0.998
2018	Ladybeetle	MC1	Tillering	Tourist herbivore	0.068	0.166	0.012	0	0.767
2018	Ladybeetle	MC1	Tillering	Detritivore	0.102	0.157	0.034	0	0.596
2018	Ladybeetle	MC2	Ripening	Rice herbivore	0.932	0.147	0.981	0.474	0.999
2018	Ladybeetle	MC2	Ripening	Tourist herbivore	0.043	0.134	0.005	0	0.465
2018	Ladybeetle	MC2	Ripening	Detritivore	0.025	0.054	0.007	0	0.169
2018	Ladybeetle	MO1	Ripening	Rice herbivore	0.935	0.145	0.981	0.465	0.999
2018	Ladybeetle	MO1	Ripening	Tourist herbivore	0.042	0.136	0.005	0	0.486
2018	Ladybeetle	MO1	Ripening	Detritivore	0.023	0.046	0.007	0	0.163
2018	Ladybeetle	MO2	Tillering	Rice herbivore	0.806	0.231	0.903	0.1	0.998
2018	Ladybeetle	MO2	Tillering	Tourist herbivore	0.084	0.176	0.015	0	0.719
2018	Ladybeetle	MO2	Tillering	Detritivore	0.11	0.161	0.041	0	0.609
2018	Ladybeetle	MO2	Flowering	Rice herbivore	0.847	0.185	0.914	0.262	0.997
2018	Ladybeetle	MO2	Flowering	Tourist herbivore	0.077	0.155	0.02	0	0.598
2018	Ladybeetle	MO2	Flowering	Detritivore	0.076	0.105	0.033	0.001	0.389
2018	Ladybeetle	MO3	Tillering	Rice herbivore	0.767	0.255	0.871	0.083	0.998
2018	Ladybeetle	MO3	Tillering	Tourist herbivore	0.1	0.188	0.017	0	0.75
2018	Ladybeetle	MO3	Tillering	Detritivore	0.133	0.188	0.051	0	0.697
2018	Ladybeetle	MO3	Flowering	Rice herbivore	0.806	0.209	0.885	0.209	0.996
2018	Ladybeetle	MO3	Flowering	Tourist herbivore	0.096	0.164	0.025	0	0.617
2018	Ladybeetle	MO3	Flowering	Detritivore	0.098	0.135	0.042	0.001	0.506
2018	Ladybeetle	SC1	Tillering	Rice herbivore	0.788	0.222	0.869	0.191	0.998
2018	Ladybeetle	SC1	Tillering	Tourist herbivore	0.08	0.156	0.017	0	0.614
2018	Ladybeetle	SC1	Tillering	Detritivore	0.131	0.17	0.052	0	0.613
2018	Ladybeetle	SC1	Flowering	Rice herbivore	0.834	0.168	0.885	0.384	0.996
2018	Ladybeetle	SC1	Flowering	Tourist herbivore	0.075	0.127	0.024	0	0.473
2018	Ladybeetle	SC1	Flowering	Detritivore	0.091	0.112	0.045	0.001	0.396
2018	Ladybeetle	SC1	Ripening	Rice herbivore	0.93	0.136	0.974	0.523	0.999

2018	Ladybeetle	SC1	Ripening	Tourist herbivore	0.042	0.126	0.006	0	0.413
2018	Ladybeetle	SC1	Ripening	Detritivore	0.028	0.043	0.01	0	0.16
2018	Ladybeetle	SO1	Tillering	Rice herbivore	0.865	0.235	0.955	0.064	0.998
2018	Ladybeetle	SO1	Tillering	Tourist herbivore	0.056	0.167	0.009	0	0.836
2018	Ladybeetle	SO1	Tillering	Detritivore	0.079	0.172	0.02	0	0.724
2018	Ladybeetle	SO1	Ripening	Rice herbivore	0.948	0.148	0.989	0.395	1
2018	Ladybeetle	SO1	Ripening	Tourist herbivore	0.035	0.14	0.003	0	0.483
2018	Ladybeetle	SO1	Ripening	Detritivore	0.017	0.044	0.004	0	0.148
2019	Both	LC1	Tillering	Rice herbivore	0.443	0.108	0.447	0.225	0.654
2019	Both	LC1	Tillering	Tourist herbivore	0.273	0.105	0.274	0.061	0.475
2019	Both	LC1	Tillering	Detritivore	0.284	0.136	0.267	0.076	0.61
2019	Both	LC1	Flowering	Rice herbivore	0.882	0.068	0.894	0.724	0.975
2019	Both	LC1	Flowering	Tourist herbivore	0.107	0.067	0.094	0.017	0.26
2019	Both	LC1	Flowering	Detritivore	0.011	0.013	0.008	0.001	0.045
2019	Both	LC1	Ripening	Rice herbivore	0.946	0.037	0.955	0.852	0.99
2019	Both	LC1	Ripening	Tourist herbivore	0.051	0.036	0.043	0.008	0.143
2019	Both	LC1	Ripening	Detritivore	0.003	0.004	0.002	0	0.014
2019	Both	LC2	Tillering	Rice herbivore	0.384	0.124	0.386	0.132	0.62
2019	Both	LC2	Tillering	Tourist herbivore	0.104	0.09	0.082	0.008	0.349
2019	Both	LC2	Tillering	Detritivore	0.511	0.142	0.511	0.226	0.801
2019	Both	LC2	Flowering	Rice herbivore	0.925	0.061	0.943	0.765	0.987
2019	Both	LC2	Flowering	Tourist herbivore	0.05	0.054	0.033	0.003	0.194
2019	Both	LC2	Flowering	Detritivore	0.025	0.023	0.019	0.004	0.089
2019	Both	LC3	Tillering	Rice herbivore	0.281	0.102	0.28	0.087	0.483
2019	Both	LC3	Tillering	Tourist herbivore	0.074	0.058	0.059	0.007	0.219
2019	Both	LC3	Tillering	Detritivore	0.645	0.116	0.645	0.42	0.878
2019	Both	LC3	Flowering	Rice herbivore	0.91	0.06	0.925	0.757	0.98
2019	Both	LC3	Flowering	Tourist herbivore	0.047	0.044	0.034	0.004	0.166
2019	Both	LC3	Flowering	Detritivore	0.042	0.036	0.032	0.007	0.139
2019	Both	LC3	Ripening	Rice herbivore	0.966	0.028	0.974	0.885	0.995
2019	Both	LC3	Ripening	Tourist herbivore	0.022	0.022	0.015	0.002	0.083
2019	Both	LC3	Ripening	Detritivore	0.012	0.015	0.007	0.001	0.051

2019	Both	LO1	Tillering	Rice herbivore	0.629	0.135	0.64	0.33	0.867
2019	Both	LO1	Tillering	Tourist herbivore	0.134	0.102	0.113	0.01	0.382
2019	Both	LO1	Tillering	Detritivore	0.237	0.133	0.216	0.042	0.545
2019	Both	LO1	Flowering	Rice herbivore	0.951	0.045	0.964	0.83	0.995
2019	Both	LO1	Flowering	Tourist herbivore	0.041	0.043	0.029	0.002	0.159
2019	Both	LO1	Flowering	Detritivore	0.007	0.01	0.004	0.001	0.03
2019	Both	LO1	Ripening	Rice herbivore	0.98	0.02	0.986	0.925	0.998
2019	Both	LO1	Ripening	Tourist herbivore	0.018	0.019	0.013	0.001	0.072
2019	Both	LO1	Ripening	Detritivore	0.002	0.003	0.001	0	0.009
2019	Both	LO2	Tillering	Rice herbivore	0.28	0.114	0.278	0.073	0.507
2019	Both	LO2	Tillering	Tourist herbivore	0.096	0.077	0.078	0.007	0.287
2019	Both	LO2	Tillering	Detritivore	0.623	0.131	0.621	0.37	0.875
2019	Both	LO2	Flowering	Rice herbivore	0.894	0.082	0.915	0.679	0.98
2019	Both	LO2	Flowering	Tourist herbivore	0.064	0.068	0.044	0.005	0.238
2019	Both	LO2	Flowering	Detritivore	0.042	0.038	0.031	0.007	0.147
2019	Both	LO3	Tillering	Rice herbivore	0.368	0.272	0.268	0.067	0.944
2019	Both	LO3	Tillering	Tourist herbivore	0.039	0.034	0.029	0.004	0.128
2019	Both	LO3	Tillering	Detritivore	0.593	0.278	0.69	0.026	0.911
2019	Both	LO3	Flowering	Rice herbivore	0.93	0.059	0.944	0.773	0.997
2019	Both	LO3	Flowering	Tourist herbivore	0.026	0.03	0.017	0.001	0.111
2019	Both	LO3	Flowering	Detritivore	0.044	0.044	0.033	0	0.16
2019	Both	LO3	Ripening	Rice herbivore	0.976	0.023	0.983	0.915	0.999
2019	Both	LO3	Ripening	Tourist herbivore	0.012	0.015	0.007	0.001	0.05
2019	Both	LO3	Ripening	Detritivore	0.011	0.014	0.007	0	0.05
2019	Both	MC1	Tillering	Rice herbivore	0.554	0.163	0.564	0.207	0.841
2019	Both	MC1	Tillering	Tourist herbivore	0.134	0.109	0.104	0.01	0.408
2019	Both	MC1	Tillering	Detritivore	0.311	0.169	0.283	0.055	0.707
2019	Both	MC1	Flowering	Rice herbivore	0.943	0.048	0.958	0.819	0.993
2019	Both	MC1	Flowering	Tourist herbivore	0.046	0.045	0.031	0.003	0.164
2019	Both	MC1	Flowering	Detritivore	0.011	0.014	0.007	0.001	0.05
2019	Both	MC1	Ripening	Rice herbivore	0.975	0.025	0.983	0.908	0.998
2019	Both	MC1	Ripening	Tourist herbivore	0.021	0.023	0.014	0.001	0.086

2019	Both	MC1	Ripening	Detritivore	0.003	0.005	0.002	0	0.018
2019	Both	MC2	Tillering	Rice herbivore	0.379	0.136	0.366	0.149	0.684
2019	Both	MC2	Tillering	Tourist herbivore	0.084	0.074	0.063	0.007	0.273
2019	Both	MC2	Tillering	Detritivore	0.537	0.156	0.548	0.189	0.805
2019	Both	MC2	Flowering	Rice herbivore	0.938	0.036	0.945	0.852	0.986
2019	Both	MC2	Flowering	Tourist herbivore	0.036	0.03	0.028	0.003	0.115
2019	Both	MC2	Flowering	Detritivore	0.026	0.019	0.021	0.004	0.077
2019	Both	MC3	Tillering	Rice herbivore	0.298	0.115	0.293	0.095	0.538
2019	Both	MC3	Tillering	Tourist herbivore	0.374	0.131	0.38	0.093	0.622
2019	Both	MC3	Tillering	Detritivore	0.328	0.161	0.305	0.077	0.707
2019	Both	MC3	Flowering	Rice herbivore	0.782	0.119	0.803	0.503	0.958
2019	Both	MC3	Flowering	Tourist herbivore	0.2	0.116	0.18	0.029	0.473
2019	Both	MC3	Flowering	Detritivore	0.018	0.02	0.012	0.002	0.077
2019	Both	MC3	Ripening	Rice herbivore	0.893	0.065	0.906	0.735	0.979
2019	Both	MC3	Ripening	Tourist herbivore	0.101	0.064	0.089	0.017	0.256
2019	Both	MC3	Ripening	Detritivore	0.005	0.008	0.003	0	0.026
2019	Both	MO1	Tillering	Rice herbivore	0.2	0.121	0.185	0.027	0.478
2019	Both	MO1	Tillering	Tourist herbivore	0.141	0.115	0.113	0.008	0.42
2019	Both	MO1	Tillering	Detritivore	0.659	0.177	0.674	0.245	0.949
2019	Both	MO1	Flowering	Rice herbivore	0.812	0.117	0.833	0.539	0.968
2019	Both	MO1	Flowering	Tourist herbivore	0.115	0.09	0.092	0.008	0.337
2019	Both	MO1	Flowering	Detritivore	0.072	0.081	0.046	0.006	0.303
2019	Both	MO1	Ripening	Rice herbivore	0.914	0.075	0.936	0.713	0.991
2019	Both	MO1	Ripening	Tourist herbivore	0.059	0.053	0.045	0.004	0.203
2019	Both	MO1	Ripening	Detritivore	0.027	0.049	0.01	0.001	0.175
2019	Both	MO2	Tillering	Rice herbivore	0.066	0.044	0.055	0.013	0.182
2019	Both	MO2	Tillering	Tourist herbivore	0.296	0.378	0.021	0.002	0.931
2019	Both	MO2	Tillering	Detritivore	0.639	0.387	0.901	0.025	0.974
2019	Both	MO2	Flowering	Rice herbivore	0.625	0.242	0.717	0.086	0.904
2019	Both	MO2	Flowering	Tourist herbivore	0.243	0.305	0.06	0.006	0.901
2019	Both	MO2	Flowering	Detritivore	0.132	0.113	0.122	0.002	0.371
2019	Both	MO3	Tillering	Rice herbivore	0.008	0.006	0.006	0.001	0.023

2019	Both	MO3	Tillering	Tourist herbivore	0.534	0.195	0.502	0.227	0.961
2019	Both	MO3	Tillering	Detritivore	0.458	0.195	0.492	0.033	0.766
2019	Both	MO3	Flowering	Rice herbivore	0.072	0.044	0.062	0.015	0.182
2019	Both	MO3	Flowering	Tourist herbivore	0.856	0.067	0.864	0.71	0.962
2019	Both	MO3	Flowering	Detritivore	0.072	0.048	0.063	0.006	0.19
2019	Both	MO3	Ripening	Rice herbivore	0.146	0.063	0.139	0.043	0.285
2019	Both	MO3	Ripening	Tourist herbivore	0.816	0.069	0.82	0.669	0.936
2019	Both	MO3	Ripening	Detritivore	0.038	0.036	0.028	0.002	0.135
2019	Both	SC1	Tillering	Rice herbivore	0.26	0.099	0.258	0.079	0.458
2019	Both	SC1	Tillering	Tourist herbivore	0.113	0.084	0.095	0.008	0.31
2019	Both	SC1	Tillering	Detritivore	0.627	0.124	0.626	0.384	0.865
2019	Both	SC1	Flowering	Rice herbivore	0.883	0.076	0.902	0.676	0.975
2019	Both	SC1	Flowering	Tourist herbivore	0.074	0.065	0.055	0.006	0.256
2019	Both	SC1	Flowering	Detritivore	0.043	0.034	0.032	0.007	0.136
2019	Both	SC1	Ripening	Rice herbivore	0.949	0.047	0.963	0.82	0.994
2019	Both	SC1	Ripening	Tourist herbivore	0.038	0.041	0.025	0.003	0.157
2019	Both	SC1	Ripening	Detritivore	0.013	0.018	0.007	0.001	0.06
2019	Both	SO1	Tillering	Rice herbivore	0.232	0.129	0.211	0.051	0.536
2019	Both	SO1	Tillering	Tourist herbivore	0.1	0.096	0.072	0.006	0.364
2019	Both	SO1	Tillering	Detritivore	0.667	0.165	0.687	0.301	0.921
2019	Both	SO1	Flowering	Rice herbivore	0.869	0.088	0.888	0.654	0.978
2019	Both	SO1	Flowering	Tourist herbivore	0.073	0.067	0.053	0.005	0.252
2019	Both	SO1	Flowering	Detritivore	0.059	0.053	0.043	0.006	0.198
2019	Both	SO1	Ripening	Rice herbivore	0.946	0.047	0.959	0.827	0.994
2019	Both	SO1	Ripening	Tourist herbivore	0.036	0.038	0.025	0.002	0.141
2019	Both	SO1	Ripening	Detritivore	0.018	0.025	0.009	0.001	0.085
2019	Spider	LC1	Tillering	Rice herbivore	0.502	0.084	0.505	0.33	0.655
2019	Spider	LC1	Tillering	Tourist herbivore	0.294	0.073	0.293	0.154	0.44
2019	Spider	LC1	Tillering	Detritivore	0.203	0.1	0.19	0.047	0.448
2019	Spider	LC1	Flowering	Rice herbivore	0.908	0.038	0.915	0.816	0.965
2019	Spider	LC1	Flowering	Tourist herbivore	0.085	0.037	0.079	0.031	0.173
2019	Spider	LC1	Flowering	Detritivore	0.007	0.007	0.005	0.001	0.024

2019	Spider	LC1	Ripening	Rice herbivore	0.945	0.027	0.951	0.878	0.982
2019	Spider	LC1	Ripening	Tourist herbivore	0.051	0.026	0.047	0.016	0.116
2019	Spider	LC1	Ripening	Detritivore	0.003	0.004	0.002	0	0.014
2019	Spider	LC2	Tillering	Rice herbivore	0.457	0.101	0.46	0.251	0.657
2019	Spider	LC2	Tillering	Tourist herbivore	0.127	0.068	0.117	0.024	0.284
2019	Spider	LC2	Tillering	Detritivore	0.416	0.122	0.411	0.191	0.67
2019	Spider	LC2	Flowering	Rice herbivore	0.942	0.032	0.948	0.865	0.985
2019	Spider	LC2	Flowering	Tourist herbivore	0.042	0.027	0.036	0.007	0.111
2019	Spider	LC2	Flowering	Detritivore	0.016	0.015	0.011	0.002	0.054
2019	Spider	LC3	Tillering	Rice herbivore	0.307	0.092	0.311	0.114	0.482
2019	Spider	LC3	Tillering	Tourist herbivore	0.05	0.031	0.044	0.008	0.126
2019	Spider	LC3	Tillering	Detritivore	0.643	0.099	0.638	0.452	0.848
2019	Spider	LC3	Flowering	Rice herbivore	0.939	0.038	0.947	0.838	0.984
2019	Spider	LC3	Flowering	Tourist herbivore	0.025	0.019	0.02	0.004	0.076
2019	Spider	LC3	Flowering	Detritivore	0.036	0.029	0.028	0.006	0.112
2019	Spider	LC3	Ripening	Rice herbivore	0.968	0.025	0.975	0.9	0.995
2019	Spider	LC3	Ripening	Tourist herbivore	0.015	0.013	0.012	0.002	0.048
2019	Spider	LC3	Ripening	Detritivore	0.016	0.019	0.01	0.001	0.072
2019	Spider	LO1	Tillering	Rice herbivore	0.74	0.089	0.744	0.556	0.9
2019	Spider	LO1	Tillering	Tourist herbivore	0.115	0.065	0.105	0.021	0.265
2019	Spider	LO1	Tillering	Detritivore	0.146	0.085	0.132	0.028	0.351
2019	Spider	LO1	Flowering	Rice herbivore	0.973	0.018	0.976	0.928	0.995
2019	Spider	LO1	Flowering	Tourist herbivore	0.024	0.017	0.02	0.003	0.068
2019	Spider	LO1	Flowering	Detritivore	0.003	0.003	0.002	0	0.012
2019	Spider	LO1	Ripening	Rice herbivore	0.984	0.011	0.987	0.955	0.998
2019	Spider	LO1	Ripening	Tourist herbivore	0.014	0.011	0.011	0.002	0.043
2019	Spider	LO1	Ripening	Detritivore	0.002	0.002	0.001	0	0.007
2019	Spider	LO2	Tillering	Rice herbivore	0.311	0.097	0.312	0.118	0.497
2019	Spider	LO2	Tillering	Tourist herbivore	0.066	0.041	0.059	0.011	0.166
2019	Spider	LO2	Tillering	Detritivore	0.623	0.11	0.621	0.413	0.843
2019	Spider	LO2	Flowering	Rice herbivore	0.932	0.04	0.942	0.825	0.982
2019	Spider	LO2	Flowering	Tourist herbivore	0.033	0.024	0.027	0.005	0.092

2019	Spider	LO2	Flowering	Detritivore	0.035	0.03	0.026	0.005	0.118
2019	Spider	LO3	Tillering	Rice herbivore	0.555	0.097	0.556	0.36	0.746
2019	Spider	LO3	Tillering	Tourist herbivore	0.126	0.07	0.117	0.02	0.288
2019	Spider	LO3	Tillering	Detritivore	0.319	0.116	0.316	0.102	0.56
2019	Spider	LO3	Flowering	Rice herbivore	0.956	0.024	0.961	0.896	0.988
2019	Spider	LO3	Flowering	Tourist herbivore	0.034	0.022	0.03	0.005	0.094
2019	Spider	LO3	Flowering	Detritivore	0.009	0.008	0.007	0.001	0.031
2019	Spider	LO3	Ripening	Rice herbivore	0.975	0.016	0.979	0.934	0.995
2019	Spider	LO3	Ripening	Tourist herbivore	0.02	0.015	0.017	0.003	0.058
2019	Spider	LO3	Ripening	Detritivore	0.004	0.005	0.003	0	0.02
2019	Spider	MC1	Tillering	Rice herbivore	0.704	0.109	0.707	0.474	0.899
2019	Spider	MC1	Tillering	Tourist herbivore	0.098	0.066	0.084	0.014	0.26
2019	Spider	MC1	Tillering	Detritivore	0.199	0.11	0.183	0.034	0.454
2019	Spider	MC1	Flowering	Rice herbivore	0.974	0.017	0.978	0.931	0.995
2019	Spider	MC1	Flowering	Tourist herbivore	0.021	0.017	0.017	0.003	0.064
2019	Spider	MC1	Flowering	Detritivore	0.005	0.005	0.003	0	0.018
2019	Spider	MC1	Ripening	Rice herbivore	0.985	0.011	0.988	0.956	0.998
2019	Spider	MC1	Ripening	Tourist herbivore	0.013	0.011	0.01	0.001	0.04
2019	Spider	MC1	Ripening	Detritivore	0.002	0.003	0.001	0	0.011
2019	Spider	MC2	Tillering	Rice herbivore	0.323	0.114	0.315	0.128	0.565
2019	Spider	MC2	Tillering	Tourist herbivore	0.101	0.063	0.089	0.016	0.251
2019	Spider	MC2	Tillering	Detritivore	0.576	0.136	0.58	0.297	0.824
2019	Spider	MC2	Flowering	Rice herbivore	0.924	0.039	0.93	0.832	0.979
2019	Spider	MC2	Flowering	Tourist herbivore	0.047	0.031	0.04	0.007	0.125
2019	Spider	MC2	Flowering	Detritivore	0.03	0.023	0.024	0.004	0.089
2019	Spider	MC3	Tillering	Rice herbivore	0.333	0.095	0.336	0.152	0.516
2019	Spider	MC3	Tillering	Tourist herbivore	0.415	0.088	0.41	0.252	0.609
2019	Spider	MC3	Tillering	Detritivore	0.252	0.117	0.237	0.064	0.518
2019	Spider	MC3	Flowering	Rice herbivore	0.82	0.074	0.832	0.646	0.93
2019	Spider	MC3	Flowering	Tourist herbivore	0.169	0.07	0.157	0.064	0.334
2019	Spider	MC3	Flowering	Detritivore	0.012	0.013	0.008	0.001	0.044
2019	Spider	MC3	Ripening	Rice herbivore	0.888	0.054	0.899	0.758	0.963

2019	Spider	MC3	Ripening	Tourist herbivore	0.106	0.052	0.096	0.034	0.234
2019	Spider	MC3	Ripening	Detritivore	0.006	0.008	0.003	0	0.026
2019	Spider	MO1	Tillering	Rice herbivore	0.217	0.114	0.199	0.055	0.498
2019	Spider	MO1	Tillering	Tourist herbivore	0.123	0.085	0.107	0.014	0.333
2019	Spider	MO1	Tillering	Detritivore	0.66	0.169	0.685	0.236	0.912
2019	Spider	MO1	Flowering	Rice herbivore	0.865	0.066	0.875	0.711	0.964
2019	Spider	MO1	Flowering	Tourist herbivore	0.078	0.046	0.071	0.014	0.189
2019	Spider	MO1	Flowering	Detritivore	0.057	0.052	0.042	0.004	0.192
2019	Spider	MO1	Ripening	Rice herbivore	0.923	0.047	0.935	0.8	0.984
2019	Spider	MO1	Ripening	Tourist herbivore	0.048	0.031	0.042	0.007	0.125
2019	Spider	MO1	Ripening	Detritivore	0.029	0.037	0.014	0.001	0.142
2019	Spider	MO2	Tillering	Rice herbivore	0.139	0.064	0.132	0.04	0.283
2019	Spider	MO2	Tillering	Tourist herbivore	0.053	0.038	0.044	0.006	0.149
2019	Spider	MO2	Tillering	Detritivore	0.808	0.081	0.814	0.629	0.939
2019	Spider	MO2	Flowering	Rice herbivore	0.854	0.072	0.866	0.687	0.959
2019	Spider	MO2	Flowering	Tourist herbivore	0.053	0.037	0.044	0.009	0.15
2019	Spider	MO2	Flowering	Detritivore	0.092	0.062	0.078	0.014	0.246
2019	Spider	MO3	Tillering	Rice herbivore	0.005	0.003	0.004	0.001	0.013
2019	Spider	MO3	Tillering	Tourist herbivore	0.497	0.186	0.464	0.218	0.947
2019	Spider	MO3	Tillering	Detritivore	0.498	0.186	0.531	0.048	0.779
2019	Spider	MO3	Flowering	Rice herbivore	0.054	0.03	0.048	0.014	0.126
2019	Spider	MO3	Flowering	Tourist herbivore	0.857	0.059	0.861	0.729	0.957
2019	Spider	MO3	Flowering	Detritivore	0.089	0.052	0.081	0.009	0.21
2019	Spider	MO3	Ripening	Rice herbivore	0.092	0.044	0.086	0.026	0.193
2019	Spider	MO3	Ripening	Tourist herbivore	0.842	0.068	0.851	0.683	0.951
2019	Spider	MO3	Ripening	Detritivore	0.066	0.058	0.049	0.003	0.214
2019	Spider	SC1	Tillering	Rice herbivore	0.229	0.093	0.229	0.057	0.412
2019	Spider	SC1	Tillering	Tourist herbivore	0.1	0.059	0.092	0.016	0.237
2019	Spider	SC1	Tillering	Detritivore	0.671	0.117	0.667	0.443	0.896
2019	Spider	SC1	Flowering	Rice herbivore	0.882	0.071	0.899	0.703	0.97
2019	Spider	SC1	Flowering	Tourist herbivore	0.066	0.046	0.054	0.011	0.186
2019	Spider	SC1	Flowering	Detritivore	0.052	0.048	0.038	0.007	0.181

2019	Spider	SC1	Ripening	Rice herbivore	0.933	0.051	0.947	0.798	0.989
2019	Spider	SC1	Ripening	Tourist herbivore	0.041	0.032	0.033	0.005	0.126
2019	Spider	SC1	Ripening	Detritivore	0.025	0.034	0.014	0.001	0.121
2019	Spider	SO1	Tillering	Rice herbivore	0.202	0.116	0.185	0.036	0.462
2019	Spider	SO1	Tillering	Tourist herbivore	0.101	0.074	0.085	0.012	0.286
2019	Spider	SO1	Tillering	Detritivore	0.698	0.145	0.71	0.391	0.929
2019	Spider	SO1	Ripening	Rice herbivore	0.917	0.066	0.936	0.747	0.988
2019	Spider	SO1	Ripening	Tourist herbivore	0.05	0.047	0.037	0.005	0.172
2019	Spider	SO1	Ripening	Detritivore	0.032	0.041	0.018	0.001	0.157
2019	Ladybeetle	LC1	Tillering	Rice herbivore	0.849	0.204	0.93	0.171	0.998
2019	Ladybeetle	LC1	Tillering	Tourist herbivore	0.071	0.164	0.012	0	0.716
2019	Ladybeetle	LC1	Tillering	Detritivore	0.08	0.126	0.028	0	0.472
2019	Ladybeetle	LC1	Flowering	Rice herbivore	0.884	0.16	0.94	0.406	0.997
2019	Ladybeetle	LC1	Flowering	Tourist herbivore	0.064	0.142	0.016	0	0.502
2019	Ladybeetle	LC1	Flowering	Detritivore	0.052	0.074	0.024	0	0.264
2019	Ladybeetle	LC1	Ripening	Rice herbivore	0.948	0.144	0.985	0.378	0.999
2019	Ladybeetle	LC1	Ripening	Tourist herbivore	0.037	0.141	0.004	0	0.611
2019	Ladybeetle	LC1	Ripening	Detritivore	0.014	0.025	0.006	0	0.083
2019	Ladybeetle	LC2	Tillering	Rice herbivore	0.831	0.225	0.925	0.112	0.999
2019	Ladybeetle	LC2	Tillering	Tourist herbivore	0.067	0.167	0.012	0	0.814
2019	Ladybeetle	LC2	Tillering	Detritivore	0.102	0.157	0.032	0	0.575
2019	Ladybeetle	LC2	Flowering	Rice herbivore	0.872	0.171	0.935	0.3	0.997
2019	Ladybeetle	LC2	Flowering	Tourist herbivore	0.063	0.142	0.016	0	0.588
2019	Ladybeetle	LC2	Flowering	Detritivore	0.065	0.096	0.027	0	0.346
2019	Ladybeetle	LC3	Flowering	Rice herbivore	0.88	0.16	0.935	0.344	0.997
2019	Ladybeetle	LC3	Flowering	Tourist herbivore	0.064	0.139	0.016	0	0.577
2019	Ladybeetle	LC3	Flowering	Detritivore	0.057	0.078	0.026	0	0.286
2019	Ladybeetle	LC3	Ripening	Rice herbivore	0.946	0.143	0.984	0.471	0.999
2019	Ladybeetle	LC3	Ripening	Tourist herbivore	0.038	0.139	0.004	0	0.473
2019	Ladybeetle	LC3	Ripening	Detritivore	0.017	0.028	0.006	0	0.099
2019	Ladybeetle	LO1	Ripening	Rice herbivore	0.94	0.138	0.981	0.46	0.999
2019	Ladybeetle	LO1	Ripening	Tourist herbivore	0.04	0.131	0.005	0	0.5

2019	Ladybeetle	LO1	Ripening	Detritivore	0.02	0.035	0.007	0	0.122
2019	Ladybeetle	LO3	Tillering	Rice herbivore	0.901	0.215	0.969	0.049	0.999
2019	Ladybeetle	LO3	Tillering	Tourist herbivore	0.054	0.179	0.007	0	0.891
2019	Ladybeetle	LO3	Tillering	Detritivore	0.045	0.121	0.015	0	0.493
2019	Ladybeetle	LO3	Ripening	Rice herbivore	0.958	0.154	0.993	0.242	1
2019	Ladybeetle	LO3	Ripening	Tourist herbivore	0.034	0.152	0.002	0	0.74
2019	Ladybeetle	LO3	Ripening	Detritivore	0.008	0.018	0.003	0	0.049
2019	Ladybeetle	MC2	Flowering	Rice herbivore	0.92	0.152	0.961	0.222	0.997
2019	Ladybeetle	MC2	Flowering	Tourist herbivore	0.05	0.146	0.011	0	0.708
2019	Ladybeetle	MC2	Flowering	Detritivore	0.03	0.037	0.017	0	0.137
2019	Ladybeetle	MC3	Flowering	Rice herbivore	0.872	0.163	0.93	0.352	0.997
2019	Ladybeetle	MC3	Flowering	Tourist herbivore	0.073	0.147	0.019	0	0.581
2019	Ladybeetle	MC3	Flowering	Detritivore	0.055	0.071	0.027	0	0.265
2019	Ladybeetle	MC3	Ripening	Rice herbivore	0.943	0.143	0.983	0.504	0.999
2019	Ladybeetle	MC3	Ripening	Tourist herbivore	0.04	0.139	0.005	0	0.466
2019	Ladybeetle	MC3	Ripening	Detritivore	0.017	0.029	0.006	0	0.1
2019	Ladybeetle	MO1	Ripening	Rice herbivore	0.92	0.165	0.98	0.346	0.999
2019	Ladybeetle	MO1	Ripening	Tourist herbivore	0.044	0.139	0.005	0	0.488
2019	Ladybeetle	MO1	Ripening	Detritivore	0.036	0.084	0.007	0	0.307
2019	Ladybeetle	MO2	Tillering	Rice herbivore	0.88	0.229	0.96	0.044	0.998
2019	Ladybeetle	MO2	Tillering	Tourist herbivore	0.081	0.219	0.008	0	0.917
2019	Ladybeetle	MO2	Tillering	Detritivore	0.039	0.068	0.018	0	0.185
2019	Ladybeetle	MO2	Flowering	Rice herbivore	0.901	0.185	0.964	0.142	0.998
2019	Ladybeetle	MO2	Flowering	Tourist herbivore	0.069	0.178	0.01	0	0.82
2019	Ladybeetle	MO2	Flowering	Detritivore	0.03	0.048	0.014	0	0.149
2019	Ladybeetle	MO3	Tillering	Rice herbivore	0.781	0.236	0.871	0.13	0.998
2019	Ladybeetle	MO3	Tillering	Tourist herbivore	0.092	0.179	0.018	0	0.736
2019	Ladybeetle	MO3	Tillering	Detritivore	0.126	0.172	0.049	0	0.625
2019	Ladybeetle	MO3	Flowering	Rice herbivore	0.826	0.185	0.886	0.271	0.996
2019	Ladybeetle	MO3	Flowering	Tourist herbivore	0.088	0.156	0.024	0	0.639
2019	Ladybeetle	MO3	Flowering	Detritivore	0.085	0.109	0.042	0	0.406
2019	Ladybeetle	MO3	Ripening	Rice herbivore	0.926	0.157	0.973	0.258	0.999

2019	Ladybeetle	MO3	Ripening	Tourist herbivore	0.05	0.151	0.007	0	0.665
2019	Ladybeetle	MO3	Ripening	Detritivore	0.024	0.037	0.01	0	0.129
2019	Ladybeetle	SC1	Flowering	Rice herbivore	0.892	0.161	0.947	0.297	0.997
2019	Ladybeetle	SC1	Flowering	Tourist herbivore	0.061	0.145	0.014	0	0.648
2019	Ladybeetle	SC1	Flowering	Detritivore	0.047	0.068	0.02	0	0.238
2019	Ladybeetle	SO1	Flowering	Rice herbivore	0.875	0.155	0.929	0.432	0.997
2019	Ladybeetle	SO1	Flowering	Tourist herbivore	0.065	0.133	0.018	0	0.475
2019	Ladybeetle	SO1	Flowering	Detritivore	0.06	0.079	0.028	0	0.287
2019	Ladybeetle	SO1	Ripening	Rice herbivore	0.943	0.139	0.982	0.546	0.999
2019	Ladybeetle	SO1	Ripening	Tourist herbivore	0.038	0.132	0.004	0	0.433
2019	Ladybeetle	SO1	Ripening	Detritivore	0.019	0.035	0.006	0	0.12

Generalist predators function as pest specialists: examining diet composition of spiders and ladybeetles across rice crop stages

Appendix C

Appendix C. Comparison of models using published trophic discrimination factors (TDFs) and TDFs derived from Caut et al. (2009):

1) We searched the literature for published TDFs for our predator taxa. We found several studies on spiders used the typical TDFs for terrestrial consumers proposed by McCutchan et al. (2003) (e.g., Mestre et al. 2013, Haraguchi et al. 2013, Sanders et al. 2014). We also found one study that published TDFs for the Lycosid spider feeding on aphids, *Drosophila*, and Collembolans (Oelbermann and Sechu 2002):

Predator	Prey	$\Delta^{13}C$	$\Delta^{15}N$	Reference
Terrestrial consumers	Invertebrates	0.50 ± 0.13	1.40 ± 0.20	McCutchan et al. 2003
Lycosid spider	Aphids	1.38 ± 0.22	1.50 ± 0.39	Oelbermann and Sechu 2002
Lycosid spider	*Drosophila*	−0.38 ± 0.10	2.16 ± 0.43	Oelbermann and Sechu 2002
Lycosid spider	Collembolans	0.02 ± 0.03	2.53 ± 0.09	Oelbermann and Sechu 2002

2) We performed a sensitivity analysis (e.g., Sanders et al. 2014) using the following new TDFs for the three prey sources to estimate the diet composition of predators (the parameter settings for the stable isotope mixing model remained consistent with those in our original analysis):

For rice herbivore TDFs, we used the TDFs for Lycosid spider feeding on aphids from Oelbermann and Sechu (2002) because many of our rice herbivores are sap feeder, similar to aphids.

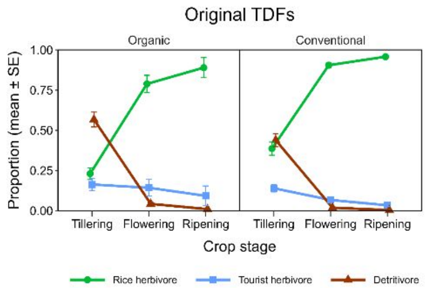
For tourist herbivore TDFs, we calculated the mean of the TDFs for Lycosid spider feeding on aphids from Oelbermann and Sechu (2002) and the TDFs for terrestrial consumers from McCutchan et al. 2003. We did not use the TDFs for Lycosid spider feeding on aphids because our tourist herbivores are not sap feeders but chewers.

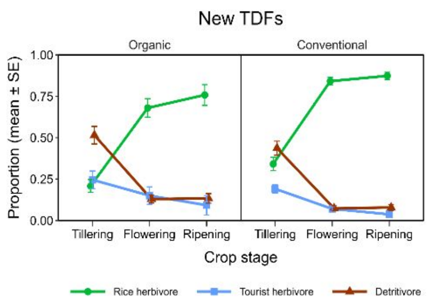
For detritivore TDFs, we calculated the mean of the TDFs for Lycosid spider feeding on *Drosophila* from Oelbermann and Sechu (2002), the TDFs for Lycosid spider feeding on Collembolans from Oelbermann and Sechu (2002), and the TDFs for terrestrial consumers from McCutchan et al. 2003. This is because our detritivores included flies and other dipterans, such as chironomidae. Note that although we did not collect collembolans in our samples, they feed on decaying materials similar to our detritivores. Therefore, we included them in the calculation of new detritivore TDFs:

Prey sources	**Original TDFs** (based on Caut et al. 2009)		**New TDFs** (based on Oelbermann and Sechu 2002, McCutchan et al. 2003)	
	$\Delta^{13}C$	$\Delta^{15}N$	$\Delta^{13}C$	$\Delta^{15}N$
Rice herbivore	1.1 ± 0.5	2.4 ± 0.6	1.38 ± 0.22	1.50 ± 0.39

Tourist herbivore	0.7 ± 0.6	2.1 ± 0.7	0.94 ± 0.18	1.45 ± 0.30
Detritivore	0.9 ± 0.3	1.5 ± 0.9	0.05 ± 0.09	2.03 ± 0.24

3) The model results based on the new TDFs listed above were generally similar to our original ones (top vs. bottom figures below), suggesting the robustness of our findings to variations in TDF values.





4) Given the following concerns that the pre-estabolished TDFs may not necessarily better reflect our study system compared to the TDFs derived from Caut et al. (2009), which are commonly used in stable isotope analysis, we decided to retain the original TDFs in the main text. However, we provide the results using pre-estabolished TDF in the Discussion (*Potential caveats of this study*) and Appendix C:

(a) Lycosid spiders, which are active-pursuit predators, may have higher metabolic rates than our studied spider taxa, which are primarily web-building sit-and-wait predators. Since metabolic rates can strongly influence isotope assimilation and enrichment processes (Martínez del Rio et al. 2009), the TDFs for Lycosid spiders may not accurately reflect those of our predators.

(b) Lycosid spiders in Oelbermann and Sechu (2002) consumed aphids, *Drosophila*, and collembolans, which differ from the primarily prey items in our study (e.g., *Nephotettix* and *Nilaparvata*; Table S1). Since prey species influence predators' stable isotope signature, using the TDFs from Oelbermann and Sechu (2002) may introduce bias into our mixing models.

(c) TDFs can be influenced by experimental conditions, such as temperature, dietary nutritional content, and predator starvation status (McCutchan et al. 2003; Vanderklift and Ponsard 2003). Since the experimental conditions in Oelbermann and Sechu (2002) unlikely reflect our field conditions, we suggest that using the average TDFs from the synthesized study by Caut et al. (2009) may be a better approach, as adopted by many studies on generalist predators (e.g., Recalde et al. 2020, Nash et al. 2023, Otieno et al. 2023).

References:

Caut, S., Angulo, E., & Courchamp, F. (2009). Variation in discrimination factors ($\Delta^{15}N$ and $\Delta^{13}C$): the effect of diet isotopic values and applications for diet reconstruction. *Journal of Applied Ecology*, *46*(2), 443-453.

Haraguchi, T. F., Uchida, M., Shibata, Y., & Tayasu, I. (2013). Contributions of detrital subsidies to aboveground spiders during secondary succession, revealed by radiocarbon and stable isotope signatures. Oecologia, 171, 935-944.

Martínez del Rio, C., Wolf, N., Carleton, S. A., & Gannes, L. Z. (2009). Isotopic ecology ten years after a call for more laboratory experiments. *Biological Reviews*, *84*(1), 91-111.

McCutchan Jr, J. H., Lewis Jr, W. M., Kendall, C., & McGrath, C. C. (2003). Variation in trophic shift for stable isotope ratios of carbon, nitrogen, and sulfur. *Oikos*, *102*(2), 378-390.

Mestre, L., Pinol, J., Barrientos, J. A., Espadaler, X., Brewitt, K., Werner, C., & Platner, C. (2013). Trophic structure of the spider community of a Mediterranean citrus grove: a stable isotope analysis. Basic and Applied Ecology, 14(5), 413-422.

Nash, L. N., Kratina, P., Recalde, F. C., Jones, J. I., Izzo, T., & Romero, G. Q. (2023). Tropical and temperate differences in the trophic structure and aquatic prey use of riparian predators. *Ecology Letters*, *26*(12), 2122-2134.

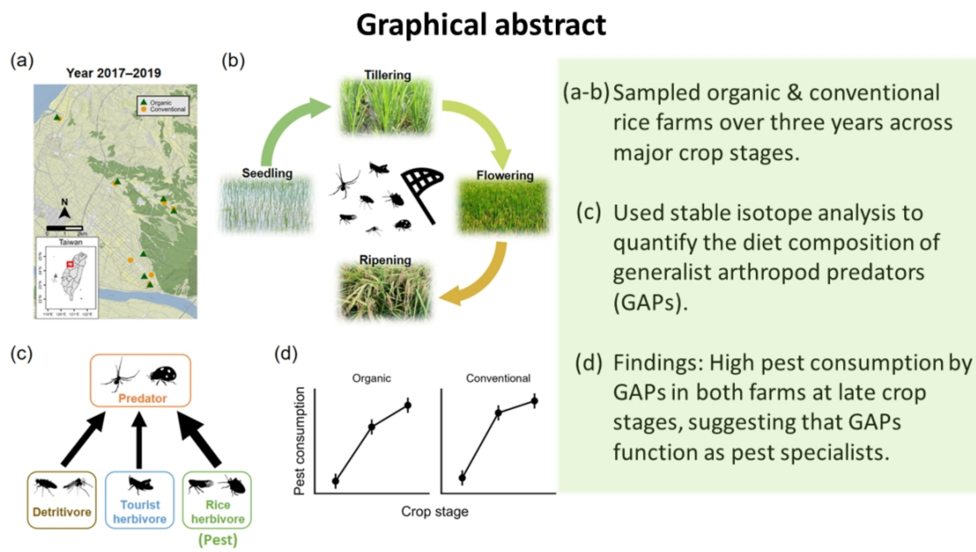
Oelbermann, K., & Scheu, S. (2002). Stable isotope enrichment ($\delta^{15}N$ and $\delta^{13}C$) in a generalist predator (*Pardosa lugubris*, Araneae: Lycosidae): effects of prey quality. *Oecologia*, *130*, 337-344.

Otieno, N. E., Butler, M., & Pryke, J. S. (2023). Fallow fields and hedgerows mediate enhanced arthropod predation and reduced herbivory on small scale intercropped maize farms–$\delta^{13}C$ and $\delta^{15}N$ stable isotope evidence. *Agriculture, Ecosystems & Environment*, *349*, 108448.

Recalde, F. C., Breviglieri, C. P., & Romero, G. Q. (2020). Allochthonous aquatic subsidies alleviate predation pressure in terrestrial ecosystems. *Ecology*, *101*(8), e03074.

Sanders, D., Vogel, E., & Knop, E. (2015). Individual and species-specific traits explain niche size and functional role in spiders as generalist predators. Journal of Animal Ecology, 84(1), 134-142.

Vanderklift, M. A., & Ponsard, S. (2003). Sources of variation in consumer-diet $\delta^{15}N$ enrichment: a meta-analysis. *Oecologia*, *136*, 169-182.



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